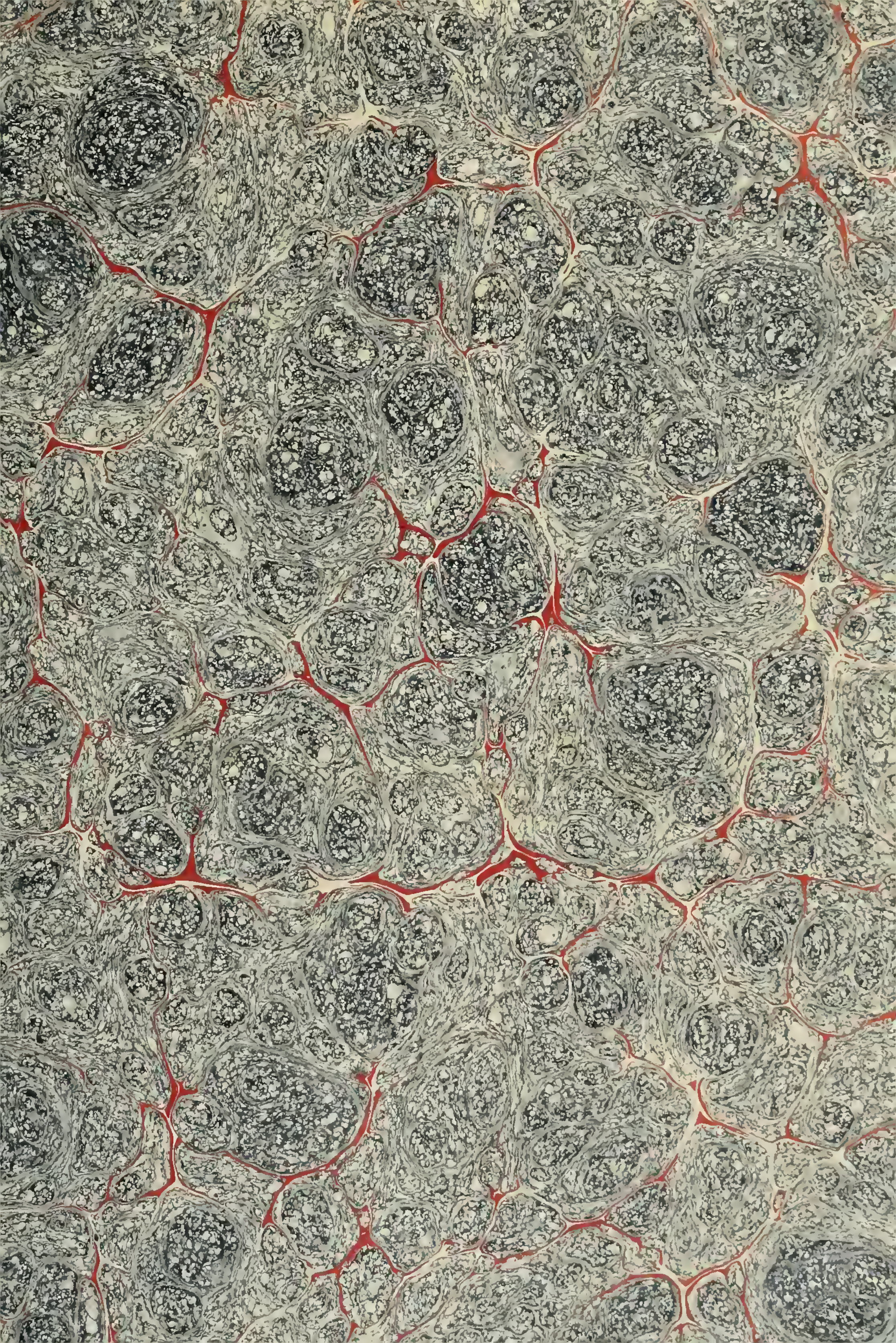
The
Robert E. Gross
Collection
A Memorial to the Founder
of the
*Lockheed Aircraft
Corporation*

Business Administration Library
University of California
Los Angeles



2 vols.

267 [illegible]

[illegible]

£8/10/-

[illegible]

T
9
J241d
1832
v.1

Knight 1852

FRONTISPIECE.

A

DICTIONARY

OF

MECHANICAL SCIENCE,

Arts, Manufactures,

AND

MISCELLANEOUS KNOWLEDGE.

COMPRISING

THE PURE SCIENCES OF MATHEMATICS, GEOMETRY, ARITHMETIC, ALGEBRA, &C.;—THE MIXED SCIENCES OF MECHANICS, HYDROSTATICS, PNEUMATICS, OPTICS, AND ASTRONOMY;—EXPERIMENTAL PHILOSOPHY;—THE FINE ARTS;—AGRICULTURE, AND ITS IMPLEMENTS;—MANUFACTURES, AND THEIR VARIOUS PROCESSES;—COMMERCE AND DOMESTIC ECONOMY;—NATURAL HISTORY;—WITH BIOGRAPHICAL AND HISTORICAL NOTICES OF EMINENT MEN, WHO HAVE ADORNED SCIENCE BY THEIR INVENTIONS AND DISCOVERIES.

Illustrated with many Hundred Engravings.

Seventh Edition.

> Studies serve for delight, for ornament, and for ability: they perfect nature, and are perfected by experience. Crafty men contemn studies simple men admire them, and wise men use them. Read not to contradict and confute, nor to believe and take for granted; nor to find talk and discourse, but to weigh and consider. Some books are to be read only in parts; others to be read, but not curiously; and some few to be read wholly, and with diligence and attention.
>
> LORD BACON.

BY ALEXANDER JAMIESON, LL.D.

LONDON:
PRINTED FOR HENRY FISHER, SON, AND CO. NEWGATE-STREET.
1832.

TO THE RIGHT HONOURABLE

FREDERICK JOHN ROBINSON, VISCOUNT GODERICH.

My Lord,

The various wants of society are supplied by the daily operations of human industry; but with the increase of society those wants accumulate, and ingenuity is then compelled to exert itself, to abridge manual labour, and render it more productive. Yet how many germs of invention blossomed before London was illumined by gas, or the vast Atlantic was navigated by a steam vessel? Three hundred years ago, the diligence of the press began to multiply the erudition of the ancients: this mighty engine has rolled on the tide of discovery in a rapid and majestic stream; the age of science has succeeded the age of literature; and a rational philosophy has invested our species with a full blaze of intellectual glory. Mankind now universally acknowledge, that we are indebted for many of the comforts, enjoyments, and delicacies of civilized life, to the prodigious improvement and extension of scientific pursuits, since the genius of observation and experiment dawned upon European society. Among the sciences which have contributed to furnish these comforts, there is none that ranks higher than Mechanics, for it is indisputable that several popular sciences are but handmaids to this; and if we look around us at all the stupendous undertakings going on in the world, we shall find them moved by machinery, or constructed by means of artificers, whose operations proceed entirely upon mechanical principles.

A Dictionary of Mechanical Science necessarily includes definitions and illustrations of numerous peculiar words and terms of expression found only in the works of those authors who have written on the Mathematical Sciences. To furnish precise ideas, and yet brief explanations, of all such words and terms, is the province of a Dictionary. But the present work embraces also the Arts, Manufactures, and various subjects of domestic economy adapted to the purposes of common life, and of course includes definitions and illustrations of numerous terms and principles scattered over the circle of Arts and Sciences, together with such other information as was deemed instructive, and subservient to a work of such universal reference.

Hence it will also be found, that all theoretical subjects are handled with brevity, while those which are practical, and applicable to the purposes of ordinary life, have been dwelt upon at length, and their relations and dependencies fully described and illustrated by appropriate Engravings; thus affording ocular as well as intellectual proof of the topics introduced to the reader's notice. And with the explanatory matter are introduced such historical facts and biographical notices as were conducive to the nature and design of the work. But while new principles and new subjects of investigation can hardly be expected in a volume, the professed object of which is to detail the discoveries and improvements of preceding writers; the most recent and original views in Science and Art, the result of modern experiments, and inventions and discoveries that are but of yesterday, obtain a place in this work; yet no novelty has been admitted here at the expense of simplicity, perspicuity, and truth.

In describing the Construction of Machines, and explaining their various uses, conciseness of expression will be no less evident than the introduction of familiar words, where their appearance tells all that was said by the pompous derivatives which too often obscure scientific writings. The principle of selection expressed in the title of the work, has afforded me ample space for many new articles of useful information in the Arts, which have hitherto been overlooked, or confined to voluminous and expensive publications. In a word, condensation of matter, and abridged descriptions, accompanied by intelligible Drawings, are the principles on which this work is constructed. Obsolete theories have been entirely omitted, and conflicting opinions disregarded, in order to present the reader with a Dictionary of subjects and ideas, rather than of words, and shreds of obscure biography.

It was impossible, however, to avoid all theory, especially in some parts of the mixed sciences; yet I am not conscious of having adopted the opinions of empyrics, or the doctrines of system makers. I have tried to follow *truth in method,* and to present my readers with a well-digested compendium of human knowledge, alphabetically arranged, and exhibiting science in a form that is indispensable to those who have little leisure for abstruse study, or have served no apprenticeship in thinking methodically. The education of the understanding, by awakening the method of self-development, was the object of the great Plato; it has been mine, without the vanity of comparison, while I introduced my readers to such relations and circumstances as might gradually inspire new sources of intellectual delight, to replenish their minds with the various sorts of knowledge most congenial to their pursuits in the different departments of Mechanical Science.

I have endeavoured, my Lord, to make my work useful rather than shining, and, from beginning to end, I have thence remembered that I was collecting information for the great body of the British Nation, who, by the "daily operations of human industry," are employed in providing for the wants of an artificial state of society. But there is a point at which the labours of every individual must stop, and he can then only look with surprise at the numerous temptations which excessive wealth holds out to needy genius in creating fresh wants, and thus reciprocally alluring pampered luxury to riot in new and untried enjoyments. Such, indeed, is civilized society in Great Britain; and there is no man who knows better the multiplicity and variety of its operations and wants than your Lordship, nor one who has more laboriously striven to alleviate the hard condition of the poor, and augment the comforts of the rich. It is, therefore, a source of much pleasure to me that my labours are honoured with the Permission of being dedicated to a Nobleman who has so deservedly won the applause of the first nation upon earth.

I have the honour to be,

My Lord,

Your Lordship's obedient and humble Servant,

ALEXANDER JAMIESON.

Wyke House,
Sion Hill, Middlesex,
Sept. 5th.

INTRODUCTION.

Science first shed her genial beams in the cheerful climes of the East; there, to use a homely phrase, her cradle was first rocked, and the curiosity of men was first awakened by the changes incessantly passing around them; but experience soon proved the constancy and regularity of this varied spectacle; and the vast movements of this stupendous and magnificent universe were all found to consist merely in a repetition of similar and uniform events.

The unfettered genius investigated physical facts by observation and experiment; observation examined the phenomena which arose in the course of nature; experiment, more artificial in its selection and combination of circumstances, searched minutely after the different results of those phenomena.

But there arose, through the ignorance and fears of mankind, a priesthood that inculcated the adoration of numberless divinities, and, proscribing the range of observation, broke in pieces the implements with which experiment had been exploring the secrets of nature. Hence the wise men of antiquity concealed their notions of science under the veil of allegory. This was the natural result of knowledge passing from the lips of unshackled genius to those of a gloomy priesthood, who employed it merely as an engine of power, and thus consigned the discoveries of happier times to the silence of despotism, and the cheerless tomb of superstition.

The two great streams of knowledge were thus soon separated widely apart,—and they continued to flow through very opposite channels. That which had pure intellection for its object, and which confined itself to morals and ethics, soon became foul and disagreeable, as, enveloped in the fog of superstition, it traversed the filthy soil of despotism;—the other, which moved through the region of physical science, preserved its purity and salubrity. Hence, while the miserable sophisms and arcana of intellectual philosophy, among the ancients, have remained the same for 3000 years; their geometry, and some branches of physical science, have, in modern times, been carried to a sublime elevation.

From the East, science travelled slowly into the early civilized nations and states of Europe. Greece first gleaned instruction in the seats of Asiatic renown, and, as the tutor of European society, she will be immortalized as having conferred eternal benefits on the human race.

Thales, after many years spent in foreign travel, transplanted into Greece the science of the Egyptian priests; and his successors, Anaximander and Anaximenes, pretended to explain the origin and formation of all things, and taught, that every substance whatever was composed of four distinct elements—earth, water, air, and fire.

It was a mere speculation, flattering to human vanity, that contemplated the stars consisting of fire, and the vital spark as a portion of its divine essence. Though we smile at these fantastic notions, they were as firmly believed in former ages by the learned as by the common people.

Anaxagoras, under the priests of Egypt and the Magi of Persia, acquired both elegance and learning.

Pythagoras, endowed by nature's choicest gifts, after thirty years' study in the East, settled in Italy, and strenuously urged the study of mathematics, especially those concerned about number and proportion. This love of numerical relations led him to cultivate music both as an art and a science, and he even transferred his ideas of this science to the harmony of the celestial motions. This was no error of Pythagoras; he could only teach the people in the temples and other public places, and to them he imparted the true system of the universe, under that noble allegory of Apollo playing on his lyre. To his chosen disciples those recondite principles of astronomical science were taught with mathematical precision; but both master and pupils affected to believe, that those bodies, while they revolved round the sun as the common centre of the universe, performed a most harmonious concert, though such ravishing and heavenly sounds were lost to the gross ears of mortals, and drowned amidst the jaring elements on earth.

Empedocles, the Sicilian, and successor of Pythagoras, conceived the doctrine of atomic attraction and repulsion. Xenophanes distinguished himself as the prince of geologists, by teaching that the fossil shells and marine exuviæ, discovered in the bowels of the earth, and on the tops of the highest mountains, had, at some remote period, been formed under the waters of the ocean. Leucippus, of the same school, added the doctrine of a separate plenum, and anticipated the influence of centrifugal force. Democritus, after visiting the East, and consulting the Magi of Hindostan, rectified many of the prevailing errors in physics. He shewed, that the existence of a plenum was incompatible with local motion; he rejected the levity attributed to the air and fire, and maintained that the weight of bodies is always proportioned to their mass or quantity of matter, and that they would hence fall in vacuo with equal swiftness. Of light and heat he entertained correct general views; and all his tenets are expounded by Lucretius.

Socrates, next in order, diffused among the Athenian youth a more solid system of education, by commending only that philosophy which is grounded on fact and experiment. The unmeasured contempt which the sage poured on hypocrisy and pretension, roused the jealousy and rage of his enemies; and the venerable man fell a martyr to the cause of truth, his love of virtue, and his devotion to wisdom.

Plato, shocked at the murder of his revered master, withdrew from the polluted city; and after visiting the Pythagoreans at Tarentum, and learning the whole system of the Italic school, next placed himself under the tuition of Theodorus, the eminent mathematician of Cyrene, in Libya. On his return to Greece, he purchased the grove of Academus, in the neighbourhood of Athens, and the youth of Greece flocked from all parts to study the beautiful method of geometrical analysis, which extended the boundaries of science, and led to the discovery of conic sections,—a doctrine which, in more recent times, taught Galileo the laws of motion, and Kepler the true orbits of the planets.

Stagira, a small town on the confines of Thrace and Macedon, gave birth to Aristotle 380 years before the age of Augustus. The authority of the Stagiran long maintained a despotic sway in the schools. Aristotle was tutor to Alexander the Great, and no philosopher has taken a wider range of disquisition, none ever discovered a greater soundness of judgment, or more precision of thought. He was the founder of comparative anatomy, and the divisions he introduced are still the best that could be made. His meteorology sparkles with fine remarks and just conclusions. His physics contain interesting doctrines, mixed up with idle and extravagant speculations. But the mind of Aristotle was drawn aside by the love of subtlety, and the illusion of general hypothesis, from the strict investigation of facts.

In the museum of Alexandria in Egypt, Ptolemy, to whose lot this country fell on the premature death of Alexander, established men of science, and provided them with books and instruments for the prosecution of their studies. The munificence of his successors aggrandized the institution by a vast library and royal observatory, which for 900 years conferred incalculable benefits on mankind. There, Euclid digested the elements of geometry, which remain to our times: there, Apollonius, Pappus, Diocles, and Nicomedes, extended the conic sections, and improved geometrical analysis; and there, too, Diophantus flourished.

Navigation extended the knowledge of mankind respecting the surface of the globe; and the Grecian colony at Marseilles had the merit of fitting out the first voyage of discovery, though Phœnicians were, without doubt, the earliest navigators that passed the pillars of Hercules. Euthymenes crossed the equator, Pythias discovered the remote Thulè; he noticed the phenomena of the tides, and determined the obliquity of the ecliptic at 23° 48′. But our reverence for the knowledge of Pythias is modified by the fact, that 700 years before the age of Julius Cæsar, the Babylonians recorded eclipses of the moon, an event in science that is marked by Hipparchus and Ptolemy. And the Indians, from whom Pythagoras derived his knowledge, have two principal epochs, one about 3000, and the other 1500 years before the Christian æra. Hipparchus flourished 140 years before our æra; and was contemporary with Ptolemy the geographer.

In the circle of mechanical science we are compelled, by the nature of our Introduction, to range, and must, therefore, notice next in order of time and genius, the illustrious Archimedes, of Syracuse in Sicily, who gave unlimited extent to the rotation of numbers, and founded the method of indivisibles, which led to the finest discoveries in geometry. In mechanics and hydrostatics he had no rival: he pointed out the centre of gravity, and determined its position in a number of figures; he unfolded the properties of floating bodies, and thus became the father of naval architecture. The vast engines which he constructed for the defence of the city of Syracuse, enabled his countrymen for three years to resist the overwhelming force of the Romans.

Of the Alexandrian school many philosophers applied themselves to mechanics, as Ctesebius, who improved the clepsydra, invented the pump, and constructed an engine for discharging arrows by means of condensed air; and Hiero not only constructed the crane, but invented machines which acted from the variable elasticity of included air, as affected by heat and cold; a principle which afterwards led Galileo and Sanctorio to the construction of thermometers, and the Marquis of Worcester to the contrivance of the steam-engine.

We look with measured contempt upon the Romans as regards science, whether in a theoretical or a practical point of view. Their studies and learning were altogether to form statesmen or orators. They invented nothing; the lever, the pulley, the crane, the capstan, and other simple machines, were employed by the ancient architects a thousand years before Rome had existence. The catapultæ and ballistæ, those compound mechanical engines of the Romans, exhibit amazing knowledge of machinery; but these or similar engines were common to the Greeks also; and we know that for ages the people of Italy ground their corn in hand-mills, with a fixed and moveable millstone. The art of naval architecture they learned from the Carthaginians; and in the destruction and annihilation of their once flourishing empire, they have amply shewn how completely destitute they were of those great and noble qualifications which distinguished their tutors the Greeks.

The Arabians, who studied geometry and astronomy, botany and chemistry, stored the palaces and libraries of their caliphs with the science of the Greeks, which they translated into their own language. About the tenth century of our æra, the use of the ten digits in arithmetic was introduced by the Arabians into Spain. As chemists, the followers of the Prophet brewed and distilled, and even the very names of our chemical vessels are Arabic; but of brewing and distillation, we know not that either the Greeks or the Romans knew any thing.

From the beginning of Constantinople, which rose like the work of a fairy genius, till the period when the Arabians spread the elements of science over Europe, the wrecks of knowledge lay buried in the convents; mental darkness brooded over the fairest lands of Christendom, and the more active spirits wasted their energies in brutal sports and savage depredations.

The Crusades opened the gates of refinement, and from the twelfth to the fourteenth century the chains of feudal tyranny were gradually broken; the middle class of men, that great bulwark of every free state, insensibly rose; and with the renovation of the human intellect, even in the benighted period of the middle ages, paper was manufactured from linen rags—the eyes of the aged were assisted by the invention of spectacles about the year 1285—and the construction of the mariner's compass having been made about the close of the thirteenth century, at Amalphia near Genoa, gave a prodigious impulse to navigation and commercial speculation. Swartz, a German monk, in 1382, extended the empire of man over nature, by the invention of gunpowder. About the beginning of the fifteenth century, the ingenuity and perseverance of Guttenberg and Schœffer, encouraged by the wealth of Faust, a rich burgess of Mentz, conferred upon mankind the art of Printing, the greatest benefit ever bequeathed on the human species, except that of speech or writing. In thirty years after its first discovery, the art of Printing was carried to a pitch which has never been surpassed.

Schoeffer, the oldest engraver also on wood, executed in 1491 a series of figures of plants and animals on wooden blocks. The clergy were now anxious to promote learning, as the only means of enriching themselves, and schools were accordingly opened in the convents and monasteries for the education of youth. In process of time, papal bulls elevated these schools to universities; and an apprenticeship of seven years, copied afterwards in the mechanical trades, completed the course of education, and made the students masters of Aristotle's tenets.

Copernicus restored the true system of the world; Purbach and Müller abridged astronomical calculations; Ubaldi and Stevinus extended the principles of mechanics and hydrostatics; Galileo discovered the laws of motion; Kepler and Tycho Brahe were men of the first order of genius as astronomers. And Napier immortalized his name by the sublime discovery of logarithms.

The alchymists, though extravagant in their pretensions, promoted experimental science, and the various societies that were established over Italy under this name, set an example that was followed all over Europe. Dr. GILBERT, in England, treated of magnetism; SNELLIUS discovered the laws of incidence and refraction, which DES CARTES simplified in the explication of other properties of light, and the brilliant phenomena of the rainbow. The application of algebra to geometry by the same skilful hand effected a memorable revolution in mathematical science.

TORRICELLI'S invention of the barometer, GUERICKE'S construction of the air-pump, the numerous mechanical inventions of DR. HOOKE, and HUYGENS, have enriched the stores of human knowledge, and added many valuable and profitable desiderata to the circle of domestic comforts and scientific pursuits.

The penetration of NEWTON, that ranged through the immensity of celestial space, could define the figure of the earth, and calculate the tides of the ocean; and he commanded geometry to preside over the properties of water, the motion of currents, the propagation of sound; and the sagacity of that genius, which has never been excelled, disclosed still greater wonders in its fine researches in optics, when it

> "Untwisted all the shining robe of day.'

MACLAURIN died in his prime, but COTES, BRADLEY, and the MARQUIS of WORCESTER, have left behind them names that are imperishable.

Without ransacking the biography of the continent for such names as BERNOUILLI, EULER, D'ALEMBERT, CLAIRAULT, LAGRANGE, PRONY, COULOMB, LAPLACE, PIAZZI, OLBERS, HARDING, MALUS, GALVANI, ORESTED, BERZELIUS, we may confine our notice to Britain, where CAVENDISH, ATWOOD, EMERSON, SMEATON, DAVY, SIR WM. HERSCHEL, JAS. WATT, PLAYFAIR, and LESLIE, of Edinburgh, and DR. OLINTHUS GREGORY, of Woolwich, have contributed largely to the advancement of mechanical philosophy, and the application of mechanical power.

On the progress of mechanical science in the abridgment of human labour, by the diversified application of steam and machinery in our manufactures and arts, it may be naturally expected that something should be said.

There can be no doubt, that these mighty auxiliaries have enabled Great Britain to compete with foreign nations in all the markets of the world; but whether the power, wealth, and stability of our country have been essentially promoted by the acquisition, may appear somewhat problematical. Unhappily, the diminution of manual labour, which enriches the merchant, tends to impoverish the working classes, and, by contracting the field in which industry might display its energies, to foster indolence and vice, which cannot but entail misery on future generations. Time, however, may find new sources of employment for productive labour, and posterity may look back on this *age of machinery*, as we look on the era when the invention of printing deprived thousands of scribes of their daily bread. But on this important and deeply interesting question, it is not the province of the author to decide.

In the compilation here presented to the reader, facts, not theories, demand his attention. The selections have been made from the most authentic sources of information to which the author could have access. These being arranged in alphabetical order, no difficulty can occur when any particular article is wanted for examination; and he flatters himself, that by the distribution of the plates, all confusion will be prevented, when references are required for the elucidation of any given subject.

In taking leave of his reader, he has not the vanity to think that his work can triumph in the omission of all error. From anomalies and defects no volume of this magnitude was, perhaps, ever wholly free. For these he has no apology to offer, and he only solicits from the considerate and candid reader, the same degree of liberality and forbearance, which, under similar circumstances, he would wish to enjoy.

A. J.

WYKE HOUSE, *June* 1827.

A

DICTIONARY

OF

MECHANICAL SCIENCE, THE ARTS, MANUFACTURES,

AND

DOMESTIC ECONOMY.

ABACK, a Sea term, indicates the situation of the sails of a vessel, when the surfaces are flattened against her masts by the wind. The sails may be taken aback, either by a sudden change of wind, or the alteration of the ship's course. They *are laid aback* to give the ship stern-way, in order to avoid some danger ahead. To *aback* sails, the men slacken the lee braces and haul the weather ones; the wind then blowing upon their front surface, drives the ship astern, unless she is restrained by some counteracting force, as when she rides at anchor, and then only the mizzen-top sail is *abacked.*

ABACUS, a small table covered with sand, on which the ancient mathematicians drew their diagrams, in the same way as children are taught to write in our Lancasterian and Bell schools.

ABACUS, in Architecture, the superior part or member of the capital of a column, serving as a crown to both. The Abacus originally represented a square tile laid over the mouth of an urn or basket. The form of the Abacus is the same in all the orders. *See* ARCHITECTURE.

ABACUS, the name also of an ancient instrument for facilitating the operations of arithmetic. This instrument is made by fixing a number of parallel chords or wires, at the distance of two diameters of one of the counters used in the calculation as represented in the engraving. A counter placed on the lowest chord signifies 1; on the second, 10; on the third, 100; on the fourth, 1000, &c. In the intermediate parallels, the counters are valued at one half the value of the chord immediately above; thus, between the 1st and 2d chord, a secondary chord may be fixed, and on it the value of the counter for 5; between the 2d and 3d chords 50, and so on. In the diagram before us, where the numbers 1824 and 1823 are represented in two compartments, the first is regularly units, tens, hundreds, thousands, 1824; in the second we read 1000, 500, 300, 20, 3; which, added together, is 1823.

MECHANICAL ARITHMETIC.

Fig. 1. The Year of the Christian Era.

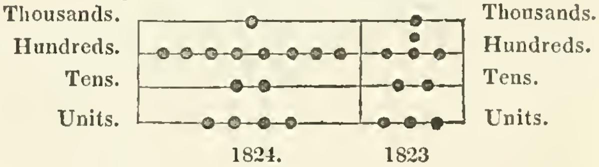
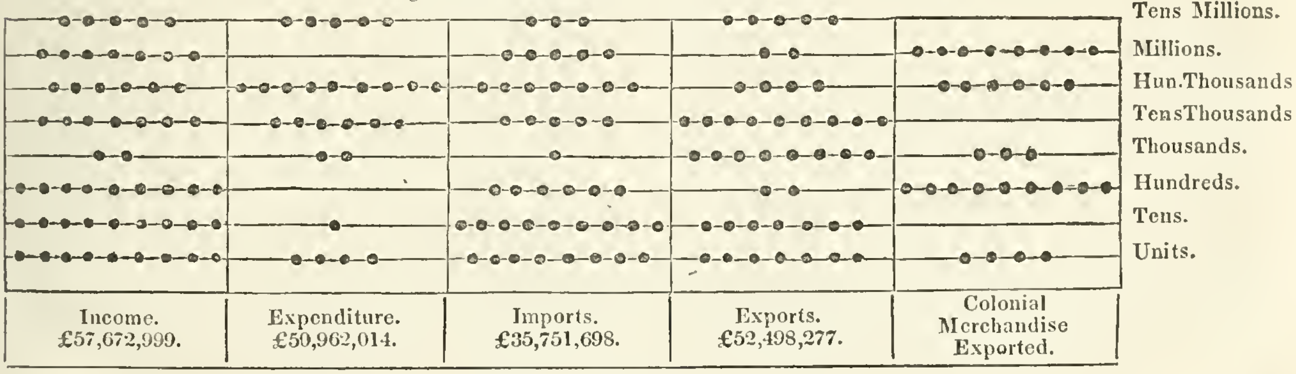


Fig. 2. Finances of Great Britain for 1823—1824.



Here the upper line reads in the Income compartment, for instance, 50,000,000; the next line, 7,00,000; the third, 600,000; the fourth, 70,000; the fifth, 2,000; the sixth, 900; the seventh, 90; and the eighth, 9:

Thus: - 50,000,000
7,000,000
600,000
70,000
2,000
900
90
9
£ 57,672,999

And in the same manner all the other compartments of the Abacus are used.

Abacus, a table of numbers ready cast up, and used by the moderns, to expedite the operations of arithmetic.

The *Grecian* Abacus was an oblong frame, over which several wires or threads were stretched, strung with ivory balls, like the beads of a necklace; by the various distributions of which, all the operations of addition, subtraction, multiplication, and division, were mechanically performed.

The *Roman* Abacus differed from the above, by having pins sliding in grooves, instead of strings or wires, and beads.

The *Chinese* Abacus corresponds with the Grecian.

The Abacus *Pythagaricus*, is the common multiplication table: the Abacus *Logisticus*, or *canon* of sexagesimals, is a rectangled triangle, whose sides forming the right angle, contain the numbers from 1 to 60; and its area the result of each two of the numbers perpendicularly opposite. The Abacus *Harmonicus* of Kircher, denotes the structure and disposition of the keys of a musical instrument. And the Abacus *Major* in metallurgic operations, is the name of a trough used in the mines for washing ore.

ABAFT, a Sea term, the hinder part of a ship; towards the stern.

ABAISSED, in Heraldry, applied to the wings of eagles, &c. when the tips droop to the point of the shield; or when the wings are shut, the natural way of bearing them being *volant*, or extended.

ABALIENATION, in Law, the act of transferring one man's property to another.

ABAPTISTON, in Surgery, the perforating part of the *trepan* instrument.

ABARTICULATION, in Anatomy, a species of articulation admitting of manifest motion; called also *Dearticulatis*, to distinguish it from that articulation which admits of very obscure motion, and is called *Synarthrosis*.

ABAS, a Persian weight for weighing pearls; one-eighth less than our carat.

ABATAMENTUM, in Law, an entry to lands by interposition: *i. e.* when a person dies, seized, and another who has no right, enters before the heir.

ABATE, in Horsemanship, the performing of any downward motion properly, as in curvets, when both the hind legs touch the ground at one and the same moment.

To Abate, a Law term:—thus, *to abate* a castle, is to pull it down; *to abate* a writ, is to defeat or overthrow it. A stranger *abates, i.e.* enters upon possession, of house or land, void by the death of him that possessed it, before the heir takes possession, and so keeps him out. The writ of the defendant *shall abate, i.e.* be overthrown. The appeal *abateth* by covin, *i. e.* the accusation is defeated by deceit.

ABATELMENT, in Commerce, a prohibition of trade to all French merchants trading to the Levant, who will not stand to their bargains.

ABATEMENT, in Heraldry, signifies an accidental figure in coats of arms, expressive of a stain, or dishonour.

Abatement, in the Customs, an allowance made upon the duties of goods that have been damaged.

ABATIS, in Fortification, an entrenchment made of felled trees, the trunks being planted in the ground, and the branches interwoven.

ABATOR, in Law, the person who enters a house or lands, on the death of the occupier, before the just heir.

ABB, among Clothiers, signifies the warp of a web, or the yarn used for warp. They also say *abb-wool*, in the same sense.

ABBA, the Syriac and Chaldee name for Father. In the Coptic and Ethiopic churches the bishops are *Abbas*.

ABBE, a Monastic term, an Abbot; latterly in France the *Abbés* were academics, tutors, &c. but not properly churchmen.

ABBESS, the superior of a convent of women. Formerly the Abbesses confessed their nuns; but female curiosity carried them such lengths in extracting secrets, that the sex were deprived of this jurisdiction over their sisters' conscience. St. Basil's rule allows the presence of an Abbess at the confessional of her nuns.

ABBEY, a Monastery, or religious house, governed by a superior, either male or female, according to its destination.

ABBOT, the superior of a monastery of monks, erected into an abbey or priory. There are various classes of Abbots, as *mitred, crosiered, ecumenical, cardinal, regular*, and *commendatory* Abbots.

ABBREVIATE *of Adjudications*, in Scotch law, an abridgment, or abstract, of a decree of adjudication, which is recorded in a register kept for that purpose.

ABBREVIATION, or Abbreviature, the contraction of a word by dropping some letters, or of a passage, by the omission of some words: as, A. U. C. *ab urbe conditâ*, from the Building of the City; I.E. *id est*, that is; E.G. *exemplæ gratiâ*, for example; A.M. before noon; P.M. afternoon.

Abbreviation *of Fractions*, reducing them to lower terms. *See* Fractions.

ABBREVIATOR, the Person who shortens or abridges any work. The Abbreviatores of the chancery at Rome are 72 clerks, who abridge all petitions, &c. for the Pope's perusal, previously to the said documents being passed into *bulls*, or ecclesiastical mandates.

ABBUTTALS, the buttings or boundings of land towards any point, distinguished anciently by artificial hillocks.

ABCEDARY Psalms, &c. whose parts are arranged according to the order of the letters of the Hebrew alphabet: as, Psalm 25, 34, 119.

ABDICATION, the action whereby a magistrate, or person in office, renounces or gives up the same before the term of service is expired; and in this wise differs from *resignation*, which implies a giving up in favour of some other person. Dioclesian abdicated; the Emperor Charles V. resigned.

ABDUCTOR, in Anatomy, the muscle that withdraws, opens, or pulls back, the parts to which it is attached.

ABELE, the hoary or white poplar, which grows very fast, and sometimes to the height of 70, 80, and 100 feet. It flourishes well in a clayey soil, on the low banks of streams, or on the margin of ponds; and the wood, which is soft and white, is much used by turners. Horses, sheep, and goats, browse upon the leaves, but cows avoid them.

ABERRATION, in Astronomy, an apparent motion of the celestial bodies, produced by the progressive motion of light, and the earth's annual motion in her orbit.

Aberration *of the Planets*, is equal to the geocentric motion of a planet; the space it appears to move, as seen from the earth, during the passage of light from it to the earth. Thus, in the sun the aberration in longitude is $20''$ constantly, that being the space moved by the earth in $8' 7''$ of time, the interval in which light passes from the sun to the earth.

ABETTOR, in Law, one who encourages another to the performance of some action. In Scots law, *art and part*.

ABEYANCE, in Law, the expectancy of an estate: hence we may say, "suc' property is in abeyance."

ABIB, the first month in the Jewish year, commencing at the vernal equinox.

ABIDING *by Writings*, in Scots law, compelling a person to abide by a false deed, as if it were true.

ABINTESTATE, in Civil Law, applied to the person who inherits the right of one who died intestate, or without will.

ABJURATION, an oath disclaiming all allegiance with a pretender: the Abjuration of *heresy*, is the solemn recantation of any doctrine as false.

ABLACTATION, in Gardening, the method of grafting by approach; *i. e.* the scyon of one tree is for some time joined to the stock of another, and afterwards cut off and weaned from the parent tree.

ABLAQUEATION, in Gardening, the operation of exposing the roots of trees in winter, to the air, rains, snows, &c.

ABLUTION, in a general sense, washing; in a religious one, the purifying of the body by water before the performance of some act of devotion. Ablutions are commanded by the Mosaic law; enjoined by the Pagan ritual; and practised by the Moslems, agreeably to the dictates of Mahomet. The priests of Egypt used daily ablutions; the Grecians, sprinklings; the Romans, lustrations; the Jews, washings and baptisms. The ancient Christians had their ablutions before communion; the Roman Catholic has his before mass, sometimes after. On Good Friday, the Syrians, Copts, &c. have solemn washings.

ABOARD, the inside of a ship: hence the phrase, to *go an board;—to board*, to enter a ship *vi et armis*, by force and arms;

—*to fall aboard*, to encounter. *Aboard main tack*, the order to draw the main tack; *i.e.* the lower corner of the main-sail down to the chess-tree.

ABOLITION, in Law, the repealing of any statute. 2. Remitting the punishment of a crime. 3. Leave given a criminal accuser to desist from further prosecution of the accused.

ABOMASUS, the fourth stomach of ruminating animals. In calves, the runnet or earning is formed in the Abomasus.

ABOMINATION *of Desolation*, foretold by Daniel, the statue of Jupiter Olympius, which Antiochus Epiphanes caused to be put up in the holy temple of Jerusalem. And the *Abomination of Desolation*, mentioned by the Evangelists, signifies the ensigns of the Romans, when Jerusalem was besieged by Titus, the son of Vespasian.

ABORIGINES, the primitive inhabitants of a country; as the blacks of Africa, the Indians of America.

ABORTION, the premature exclusion of a fœtus. The horrid crime of procuring abortion was prohibited by Solon and Lycurgus; allowed by the Romans till the time of the emperors Severus and Antonine; and practised by dispensation under the Roman ecclesiastical law!

ABOUT *Ship:* the order to the ship's crew for tacking. The situation of a ship immediately after she has tacked.

ABRAHAMITES, an order of monks, exterminated by Theophilus in the 9th century. Also the name of another sect of heretics, who had adopted the errors of Paulus, and who were thence called Paulicians.

ABRASAX, the supreme God of the Basilidian heretics; *i. e.* of the 365 heavens, or 365 revolutions of the earth on its axis. In each of those heavens was placed an angel of intelligence, that created it, and each angel was created by that immediately above it, till the scale reached the first Creator.

ABRASION, in Medicine, the effect of sharp corrosive medicines in humours, in wearing away the natural mucus that covers the intestines and stomach.

ABRAUM, a red clay brought from the Isle of Wight, with which cabinet-makers darken and polish mahogany. The best thing for polishing mahogany is, after all, linseed oil, and regular rubbing with a piece of flannel.

ABREAST, a Sea term, side by side, or opposite to, as when two ships have their sides parallel, and heads equally advanced. In line *abreast*, a fleet advances uniformly, equally distant and parallel, the length of each ship forming a right angle with the extent of the squadron. The commander is then in the centre. *Abreast*, within ship, on a line with the beam, main hatchway, &c. From this point we reckon our position *fore* or *aft*, as we stand between the beam and the bows, or stern.

ABRIDGMENT, the reduction of any thing into a smaller compass.

ABROGATION, in Law, the act of abolishing, by authority of the law maker.

ABROMA, in Botany, a stove bark tree, that grows freely in common garden soil, and may easily be propagated by seeds or cuttings.

ABRUS, in Botany, the knobbed-rooted wild liquorice.

ABSCESS, in Surgery, a collection of puriform matter in a part; properly, a cavity containing *pus*, or matter.

ABSCISS, ABSCISSA, ABSCISSÆ, in Conics, is any part of the diameter or axis of a curve, comprised between any fixed point, where all the abscisses begin, and another line called the ordinate, which is terminated in the curve. Commonly the abscisses are considered as commencing at the vertex of the curve; but this is not necessary, as they may have their origin in any other point; but generally, when no condition is specified, they are understood as commencing at the vertex. Thus, if AQ be any curve, and A, or A', or A'', certain fixed points, of which, in the annexed figures, A and A' are at the vertices, but A'' any point whatever in the axis; also PQ any line perpendicular, or otherwise, to the axis A, A', and terminating in the curve; then is PQ an ordinate, and AP, $A'P$, $A''P$, *abscisses*. The absciss and corresponding ordinate, considered together, are, by Geometricians, called co-ordinates, and by means of these the equation of the curve is defined. *See* CURVE.

Fig. 3.

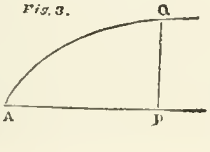
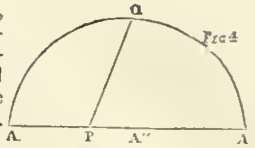


Fig. 4



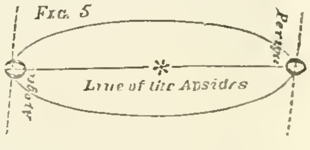
ABSCONSA, a dark lantern, used by the Monks in burying the dead at night.

ABSENCE, in Law, non-appearance when cited before a court. No person can be tried criminally in absence.

ABSINTHIATED, in Medicine, tinged with wormwood, or absinthium. The wormwood wine of the ancients, infused in draughts, proved beneficial in cases of indigestion, or debility of the stomach.

ABSIS, in Astronomy, the same with *apsis*, those two points of a planet's orbit, where it is at its greatest and least distance from the sun, &c. The line connecting these points is called the line of the apsides. The apsis at the greatest distance from the sun is called the *aphelion*, at the greatest distance from the earth, the *apogee*; at the least distance from the sun, the *perihelion*; at the least distance from the earth, the *perigee*.

FIG. 5



ABSOLUTE *Term* or *Number*, in Algebra, is that which is completely known, and to which all the other part of the equation is made equal; thus in the equation $x^2+ax=b$, the latter quantity b, is called the absolute term, which in every equation is equal to the continued product of all its roots.

ABSTRACT, or *Pure*, MATHEMATICS, treat of the properties of magnitude, figure, or quantity, absolutely and generally considered, without restriction to any species in particular, such as Arithmetic and Geometry. It is thus distinguished from *Mixed Mathematics*, in which simple and abstract quantities, primitively considered in Pure Mathematics, are applied to sensible objects, as in Astronomy, Mechanics, Optics, &c.

ABSTRACT *Numbers*, are assemblages or units, considered independently of any things, that they might otherwise be supposed to represent. For example, 5 is an abstract number, while it remains independent; but if we say 5 feet, or 5 miles, it is no longer an abstract, but a *concrete* number.

ABSOLUTION, in Civil Law, a sentence pronouncing an accused person innocent. In Canon law, the judicial act whereby the priest declares the sins of such as are penitent to be remitted.

ABSORBENT, swallowing up. Absorbent *medicines* are testaceous powders, or calcareous earths, as chalk, &c. which, taken inwardly, dry up acid and redundant humours in the stomach.

ABSORBENTS, or Absorbing Vessels, in Anatomy, are the lacteal, lymphatic, and inhalent arteries, which imbibe all those fluids that come in contact with them; but are themselves so minute as to escape observation in ordinary dissections.

ABSTRINGENT *Medicines*, such as are used for resolving obstructions, concretions, &c. such as soap, &c.

ABSURD, or ABSURDUM, a term employed in demonstrating converse propositions, in which the proposition is not proved in a direct manner, by principles before laid down; but it proves that the contrary is absurd, or impossible; and thus indirectly demonstrates the truth of the proposition itself. The 4th proposition of the 1st book of Euclid is demonstrated by this method, by shewing, that if the extremities of two right lines coincide, the lines themselves will coincide in all their parts, otherwise they would enclose a space, which is *absurd*, being contrary to the 10th axiom. Converse propositions are commonly proved in this way, which is called *reductio ad absurdum*: but it is unsatisfactory; yet it would be difficult to devise any system of geometry in which such a method should be entirely excluded.

ABUNDANT *Number*, in Arithmetic, a number, the sum of whose aliquot parts is greater than the number itself: thus, 12 is an abundant number; for the sum of its aliquot parts $1+2+3+4+6=16$, which is greater than 12. It is thus distinguished from a perfect number, which is equal to the sum of all its aliquot parts, and from a deficient number, which is less than the sum of all its aliquot parts.

ABYSS, something profound, and, as it were, bottomless, as the ocean, hell; but more properly, the temple of Proserpine, on account of the vast treasures there deposited.

Abyss, in Heraldry, the centre of an escutcheon; hence the phrase, "he bears azure, a flower-de-lis, in abyss;" *i. e.* in the middle of the shield, clear from every other bearing.

ACACIA, in Botany, the Egyptian thorn, one of the handsomest trees that adorn our pleasure-grounds. Cuttings strike in sand, under a hand-glass, in the bark bed. Of the flowers of a species of the Acacia, the Chinese make a fine yellow dye. The process is merely boiling and extraction, with the addition of a small quantity of alum, and oyster shells calcined.

Acacia, in the Materia Medica, is a mild astringent, useful in the spitting of blood; imported from Egypt, and simply the inspissated juice of unripe sloes.

ACADEMY, a School, or place of learning; a collegiate seminary; a riding-school, &c.; a society of learned men, established for the improvement of the sciences, arts, &c.

ACANTHA, the prickle of a plant, or spine of a prickly fin on a fish.

ACANTHABOLUS, in Surgery, an instrument for pulling thorns and the like out of the skin.

ACANTHUS, in Botany, the plant bear's breech, which, as a dye, gives a fine yellow; in Architecture, an ornament representing the leaves of the Acanthus, and decorating the capitals of the Corinthian and Composite orders.

ACARAUNA, a small American fish, called, by our sailors, *old wife*.

ACARUS, the tick, or mite.

ACATHARSIA, an impurity of the blood and humours.

ACAULIS, applied to those plants whose flowers are without stalks, and rest on the ground, as the *Carline thistle*.

ACCAPITARE, in Law, the act of becoming vassal of a lord, or of yielding him homage or obedience; hence *Accapitum*, or money paid by a vassal upon his admission to a feu.

ACCEDAS *ad Curiam*, a writ lying where the man has received, or fears, false judgment in an inferior court.

ACCELERATION, in Mechanics, the increase of velocity in a moving body. *Accelerated* motion is that in which the velocity is continually increasing, from the continued action of the motive power. *Uniformly accelerated* motion, is that in which the velocity increases equally in equal times. The increasing velocity with which a body falls to the earth, is an instance of accelerated motion, which is caused by the constant action of gravity. A cannon-ball is acted on by a single impulse of the powder, and the accelerating force of gravity; it therefore describes a curve: this is the foundation of the art of gunnery. A new impression being made upon a falling body at every instant, by the continued action of gravity, and the effect of the former still remaining, the velocity continually increases. Suppose a single impulse of gravitation, in one instant, to give a falling body one degree of velocity; if after this the force of gravitation were suspended, the body would continue to move with the same degree of velocity, without being accelerated or retarded. But because the attraction of gravitation continues, it produces as great a velocity in the second instant as in the first; which, added to the first, makes the velocity in the second instant double the first. In like manner, in the third instant, it will be tripled; quadrupled in the fourth; and in every instant, one degree of velocity will be acquired, and added to that which the body had before; that is, the motion will be uniformly accelerated.

Hence, then, from the preceding principles and reasoning, we deduce the following general laws of uniformly accelerated motions; *viz.*

The velocities acquired are constantly proportional to the times.

The spaces are proportional to the squares of the times; so that if a body describe any given space in a given time, it will describe four times that space in a double time, nine times that space in a treble time, and so on. And universally, if the times be in arithmetical proportion, as 1, 2, 3, 4, &c. t, the spaces described will be as 1, 4, 9, 16, &c., t^2. Thus a body, which falls by gravity through $16\frac{1}{12}$ feet in the first second, will fall through $64\frac{1}{3}$ feet in two seconds, and so on. And since the velocities acquired in falling are as the times, the spaces will be as the square of the velocities; and both the times and velocities will be as the square roots of the spaces.

The spaces described by a falling body in a series of equal moments, or intervals of time, will be as the odd numbers, 1, 3, 5, 7, 9, &c. which are the differences of the squares or whole spaces; that is, a body which falls through $16\frac{1}{12}$ feet in the first second, will fall through $3 \times 16\frac{1}{12}$ in the second, $5 \times 16\frac{1}{12}$ in the third, and so on.

Acceleration *of Bodies on Inclined Planes*. The same general law prevails here as in perpendicularly falling bodies; the plane merely making the motion slower; but the inclination being every where equal, the retardation arising therefrom will proceed equally in all parts at the beginning and the ending of the motion: and the Acceleration *of the Motion of Pendulums*, is in a less ratio than that of bodies falling perpendicularly. The Acceleration *of the Moon*, is her increase of mean motion, from the sun, compared with the diurnal motion of the earth; being about $10''$ in 100 years.

Acceleration *of a Planet*, when the real diurnal motion exceeds the mean diurnal motion. And a planet is retarded when the mean motion exceeds the real diurnal motion. This inequality arises from the change in the distance of the planet from the sun, which is continually varying; the planet moving quicker in its orbit when nearer the sun, and slower when further from him.

ACCENT, in Speaking, an inflexion of voice; in Grammar, a certain mark placed over a word or syllable.

ACCEPTANCE, in Law, agreeing to offers made in bargaining; in Commerce, signing one's name, or making one's self debtor for the sum contained in a bill of exchange.

ACCEPTILATION, among Civilians, a discharge given by a creditor to the debtor, without the payment of any value.

ACCESSION, in Law, the property of the accessory, as the calf of a cow becomes the property of her owner. Accession in Medicine, the paroxysm of a disease; in Politics, it signifies a prince's succeeding to the throne of his father or predecessor.

ACCESSORY, something that accedes, not principal: guilty by participation, *before* or *after* the fact.—Accessory *Nerves*, in Anatomy, arise from the medulla in the vertebræ of the neck, pass through the skull, and distribute themselves again in the neck and shoulders.—Accessory, in Painting, denotes arms, vases, &c. which in historical pieces may be left out.

ACCIDENT, in Heraldry, an additional point in a coat of arms, which may be omitted or retained, without altering the essence of the armour.

ACCIDENTAL *Point*, in Perspective, is a point in the horizontal line, in which a right line drawn from the eye, parallel to another right line, intersects the picture or perspective plane. This is also the accidental point of all other lines parallel to the original line, since the same line drawn from the eye is parallel to them all; and the representations of all these parallels, when produced, concur in the accidental point. *See* Perspective.

ACCLIVITY, the slope or steepness of a line or plane inclined to the horizon, taken upwards, in contradistinction to declivity, which is taken downwards. So the ascent of a hill is an *acclivity*, and the descent of the same a *declivity*.

ACCOMPANIMENT, in Music, an instrument that accompanies the voice to give it effect, or make the music more full. In Painting, such objects as are added for ornament or fitness to the chief figures, as dogs, guns, &c. In Heraldry, any thing added to the shield for ornament, as the belt, mantling, supporters.

ACCOMPLICE, an accessory, privy to a crime with another.

ACCOMPLISHMENT of Prophecy, the fulfilment, under the New Testament, of events foretold by the Jewish prophets under the Old Testament.

ACCORD, in Painting, the harmony that prevails among the lights and shadows of a picture.

ACCOUNT, or Accompt, a computation or reckoning of any thing by numbers, as a transaction in business: and Accountant is a person skilled in accounts; or a bookkeeper to the South Sea or East India Company.

ACCUMULATION of Degrees, in an University, the taking of several degrees together; or at shorter intervals than the rules of the academy allow.

ACE, a card or die with one point only.

ACENTATUM, or Acenteta, a name given by the ancients to the purest and finest kind of rock crystal. In the isle of Arran, there are found rock crystals that vie with Brazilian diamonds.

ACER, in Botany, the *Maple* or *Sycamore Tree*. *See* Maple.

ACETABOLUM, in Anatomy, a cavity in any bone, for receiving the protuberant head of another. In Botany, the trivial name of a species of the peziza, or cappeziza, a genus belonging to the cryptogamia fungi of Linnæus.

ACETOSA, Sorrel.—Acetosella, a species of *oxalis*.—Acetous, partaking of the nature of vinegar.

ACETATE of Potash, known also as *regenerated tartar*, *essential salt of wine*, &c.: may be formed by saturating carbonate of potash with distilled vinegar, and by evaporating the solution slowly to dryness. This salt has a pungent alkaline taste; exposed to the air, it becomes moist; is soluble in water; when heated, it melts and froths up, and is then decomposed and charred.

ACETUM, vinegar, the vegetable acid of chemists.

ACHAN, in Medicine, a species of *herpes*.

ACHARNER, a star of the first magnitude in the constellation Eridanus.

ACHILLEA, an artificial grass, called milfoil, yarrow, and sneezewort. This grass succeeds best in a good lawn; and may be sown 12 lbs. to an acre.

Tendo Achilles, in Anatomy, a strong tendon of the heel of the foot.

ACHROMATIC, a term applied to those telescopes in which the aberrations of light are remedied, and the colours justly reflected.

ACID for Punch. Bake red currants, and strain them as for jellies; take a gallon of the juice, put to it two quarts of new milk; crush pearl gooseberries when full ripe, and strain them through a coarse cloth; add two quarts of the juice, and three pounds of double-refined sugar, three quarts of rum, and two of brandy, with one ounce of isinglass dissolved in the liquor: mix it all up together, and put it in a little cask. Let it stand for six weeks, and then bottle it for use. This acid will keep for many years. But, after all, lemon juice is the best acid for punch.

Acids and their Salts. Acids are either solid, liquid, or gaseous. They have so strong an attraction for water, as to be generally incapable of appearing in a solid form.

The general characteristic Properties of Acids.

1. They are sour when applied to the tongue.
2. They change vegetable blues to a red colour.
3. They combine with metals and metallic oxides: among the latter are included earths and alkalis; with all these they form salts.
4. They combine with water in all proportions. In this state, they are said to be diluted. Very many contain oxygen as one of their components: but this substance is by no means a necessary ingredient in acids; for there are several which possess the above properties, which do not contain oxygen.

All the acids combine with the alkalis. These combinations have been termed neutral salts. Example—sulphate of soda, which is produced by a combination of sulphuric acid with soda. These salts are easily formed by art: and nature exhibits a great number, especially of those which are formed by acids of simple radicals; example—sulphate of lime.

Neutral salts are distinguished by two names; one expressing the acid, and the other the alkaline base; example—sulphate of lime is composed of sulphuric acid and lime.

All metallic substances combine with at least some of the acids; example—sulphate of iron is formed by the union of iron with sulphuric acid.

When a metallic substance is put into an acid, the first requisite, in order that it may dissolve, is, that it become oxidated in it, the acid first giving up a part of its oxygen to the metal; or rather, by decomposing water which may be present: the oxygen combining with the metal, whilst the hydrogen is set free.

In metallic solutions, an effervescence, or disengagement of gas, often takes place. The gas disengaged by nitric acid, is nitric gas; that disengaged by sulphuric acid, is sulphurous acid gas, provided this acid has furnished the oxygen; but it is hydrogen gas, if the oxygen has been furnished by the water.

In general, the metals do not take from these acids all their oxygen; they do not reduce the one to azote, and the other to sulphur; but to nitrous gas, and sulphurous acid, which cannot exist but in a gaseous state.

Metallic substances dissolve without effervescence, when they have been previously oxidated; example—white oxide of lead will dissolve in acetic acid when metallic lead will not.

A metal does not dissolve with effervescence in oxygenated muriatic acid, or chlorine.

Silver, mercury, and lead, are not soluble in muriatic acid, when exposed to it in their metallic state; but if previously oxidated, they are exceedingly soluble, and the solution takes place without effervescence.

Table of the chief acids, whose general properties deserve to be known.

I. Mineral Acids.

1. Sulphurous.
2. Sulphuric.
3. Nitrous.
4. Nitric.
5. Muriatic, or Hydrochloric.
6. Chloric.
7. Carbonic.
8. Fluoric.
9. Boracic.

II. Metallic Acids.

10. Arsenious.
11. Arsenic.
12. Tungstic.
13. Molybdic.
14. Chromic.
15. Columbic.

III. Vegetable Acids.

16. Acetic, or Acetous.
17. Malic.
18. Oxalic.
19. Citric.
20. Tartaric.
21. Benzoic.
22. Camphoric.
23. Gallic.
24. Succinic.
25. Suberic.

IV. Animal Acids.

26. Phosphorous.
27. Phosphoric.
28. Bombic.
29. Sebacic.
30. Laccic.
31. Lactic.
32. Saccho-lactic.
33. Uric.
34. Prussic.
35 Pyroligneous.

The salts produced by the union of any acids, which end in *ous*, have their termination in *ite*. Thus, sulphur*ous* acid and potash form sulph*ite* of potash. Neutral salts formed by acids ending in *ic*, have their terminations in *ate*, thus, sulphur*ic* acid and potash form sulph*ate* of potash.

Sulphurous Acid is sulphur combined with oxygen, but not to saturation. It is the sulphurous acid gas when absorbed by water. The salts formed by the combination of this acid with different bases, are called sulph*ites;* they are not employed for any useful purpose.

Sulphuric Acid, formerly called oil of vitriol, is formed by the combination of sulphur, which is its base, and oxygen. Sulph*ates* are neutral salts, formed by the sulphuric acid with certain bases. Sulphate of potash, formerly called vitriolated tartar, is produced by the combination of the sulphuric acid and potash. It is found frequently in mineral waters. Sulphate of soda, commonly called Glauber's salt, is formed by the combination of soda with the sulphuric acid. The sulphates of iron and copper are used in dyeing, &c. Sulphate of lime, or plaster of Paris, is used for making casts, busts, &c.

Nitrous Acid exists in the state of gas, in the form of a red vapour; it is nitrous gas combined with a quantity of oxygen. Nitrous acid is procured from sulphate of iron, deprived of its water of crystallization by heat, and an equal weight of dry nitrate of potash. It may also be obtained by decomposing nitrate of potash, by means of sulphuric acid, with the assistance of heat. The salts formed with this acid are very little known.

Nitric Acid. The constituent principles of this acid are oxygen and nitrogen. It differs from the last mentioned acid, only in not having any nitrous gas in a loosely combined state. Oxygen and nitrogen with caloric, form nitrous gas. This gas, with a greater quantity of oxygen, forms nitric acid. Nitric acid is transparent, liquid, and colourless; sold in the shops by the name of aqua-fortis. It is procured by re-distilling nitrous acid, or at least heating it till it is deprived of its fumes. The combination of nitric acid with different bases, are called *nitrates.* Nitrate of silver is the lunar caustic used by surgeons. It is also used in making indelible ink for marking linen. These salts have the property of detonating with, or inflaming, charcoal, and other easily inflammable bodies, at a red heat. It is upon this property that the composition of gunpowder is founded, which consists of five parts of nitrate of potash, or salt-petre, one of charcoal, and one of sulphur.

Muriatic or Hydrochloric Acid, formerly termed marine acid, or spirit of salt, is composed of hydrogen and chlorine. Its combinations with earths, alkalis, and metals, form hydrochlorates or muriates. Muriate of potash, formed by the combination of muriatic acid with potash, is found in sea-water and old plaster: it has a strong, bitter, disagreeable taste. Muriate of soda, (marine, common, or rock salt,) formed by the combination of muriatic acid with soda, is found native in mines, in many places, but particularly in Poland and Hungary. It is also obtained from sea-water by evaporation, &c. Muriate of ammonia, or sal-ammoniac, formed by the combination of muriatic acid with ammonia, is found native in mines, in many parts, particularly in the neighbourhood of volcanoes. Muriate of lime is found in mineral waters of the sea, to which it contributes to give their bitter taste. Muriate of barytes is not known to exist native. Muriate of lead is the pigment or paint known by the name *patent yellow.*

Chloric Acid, formerly called oxygenated muriatic acid, is muriatic acid deprived of its hydrogen. It removes the stain of common ink, though it does not affect printer's ink. It is, therefore, used for cleaning books and prints. Half an ounce of minium or red oxide of lead, being added to three ounces of muriatic acid, will render it fit for this purpose. Nitro-muriatic acid, called formerly aqua-regia, is an acid analogous to chloric acid. This acid has the property of dissolving gold and platina, which cannot be acted upon by any other acid. Chlorate of potash, or oxygenated muriate of potash, is made by introducing the chlorine gas into a solution of potash. This salt has the property of detonating with sulphur, charcoal, &c. and has been used for making gunpowder; but the manufacture and use of this powder are very dangerous.

Carbonic Acid exists in the gaseous state, and, in combination with different bases, constitutes the salts termed carbonates. Carbonate of potash is made by exposing a solution of potash to the carbonic acid gas until saturated. Carbonate of soda is decomposed by quicklime, by the acids, and by fire, so also is the former carbónate. Carbonate of ammonia, or concrete volatile alkali, may be obtained from any animal substances, but it is not found native; it is a combination of carbonic acid with ammonia. Carbonate of barytes has no taste, is not altered in the air, is almost insoluble in water, but is decomposed by heat, and by all the acids. Carbonate of magnesia, or common magnesia, is obtained by precipitation with the carbonate of soda, from the sulphate of magnesia. It loses its water and acid by calcination, the residue being pure magnesia, sometimes called calcined magnesia.

Fluoric Acid is composed of fluorine and oxygen. In a gaseous state, it forms fluoric acid gas; united to water, it constitutes liquid fluoric acid. It exists completely formed in fluate of lime, known under the name of flour or Derbyshire spar. The distinguishing property of the fluoric acid is, its power of dissolving silex, and being employed for etching on glass.

Boracic Acid is a concrete acid extracted from borax, a salt brought from India: its base is unknown. Boracic acid exists in brilliant white scales, soft, and unctuous to the touch. Its taste is bitterish, with a slight acidity. Borate of soda, or borax, formed by the combination of the boracic acid with soda, is found in a crystallized state at the bottom of certain salt lakes, in a barren volcanic district of the kingdom of Thibet. A still purer kind comes from China. When reduced into a white opaque light, it is called calcined borax.

Arsenious Acid is metallic arsenic, oxygenated in the first degree, and therefore called arsenious acid. The white arsenic of the chemists' shops is chiefly obtained from the arsenical ores of cobalt.

Arsenic Acid, produced only by art, appears in the form of a white powder. All the preparations of arsenic are deadly poisons; the hydro-sulphurets are the best antidotes. A weak solution of hydro-sulphuret of potash, soda, or lime, is therefore often administered with success, if given in time, to persons who have been poisoned by arsenic. Sulphurous, mineral, or the Harrowgate water, may also be given. In such cases, oil, milk, butter, &c. which are too often resorted to, should never be employed, if a sulphuret, or hydro-sulphuret, can possibly be procured.

Tungstic Acid is procured from a mineral called tungsten, which is a combination of this acid with lime, (tungstate of lime,) or from wolfram, which is this acid united to iron and manganese.

Molybdic Acid is molybdena oxygenated; for this metal is susceptible of oxygenation to such a degree as to become a concrete acid.

Chromic Acid is found combined with oxide of lead, in the mineral called chromate of lead, or the red lead of Siberia; also united to iron, alumine, and silex, in the substance called chromate of iron. This acid has the peculiar property of forming the most brilliant colours with whatever metal it combines: chromate of lead is an intense yellow, chromate of mercury a brilliant red, and chromate of silver a beautiful violet.

Columbic Acid is found in the lately discovered ore called columbium, or columbate of iron.

Acetic, or Acetous Acid, exists, mixed with other substances, in common vinegar. Since this acid is very volatile, it is obtained pure by distilling vinegar in a sand-heat. In this state, it is called distilled vinegar. Its base is carbon, hydrogen, and oxygen. The same substances form the bases of the other vegetable acids, but in different proportions. The acetites of potash and soda are obtained by neutralizing the carbonates of these alkalis with acetous acid, and evaporating and crystallizing the solution. Acetate of lead, or sugar of lead, is composed of lead and acetic acid: hence, acetic acid for preparing aromatic vinegar, is usually obtained by pouring sulphuric acid on the sugar of lead in a retort, and distilling the acetic acid in a receiver prepared for the purpose. Here we have an example of decomposition: for the sulphuric acid must combine with the lead before the acetic acid will come over. This distillation must be carried on in a sand-bath. Aromatic vinegar is merely acetic acid with a little camphor and oil of bergamot dissolved in it.

Malic Acid is found in the juice of unripe apples, and some other fruits.

Oxalic Acid is prepared from sugar by mixing it with nitric acid. It is highly poisonous, and many deaths have occurred, sometimes through the negligence even of druggists, by mistaking it for Epsom salts, which are very like it.

Citric Acid is found in the juice of lemons and oranges unripe grapes, and other sour fruits. It is also called concrete lemon juice, and is used for a variety of purposes. It is a very useful substance for taking stains of ink out of linen.

Tartaric Acid. The tartar found adhering to wine casks, is a salt composed of a peculiar acid combined with potash, but in such a manner, that the acid is in considerable excess. The salt is known under the name of acidulous tartrite of potash, and the acid which enters into its composition is the tartaric. It is by the combination of this acid with potash, that the acidulous tartrite of potash, usually called cream of tartar, is formed by solution, with subsequent filtration and evaporation.

Benzoic Acid is found in the resin, called benzoin, in the balsam of Peru, and some other substances of this kind. It is also found in urine, and other animal substances.

Camphoric Acid, is camphor oxygenated to acidity. Camphor is a concrete essential oil, extracted by sublimation from a laurel which grows in China and Japan.

Gallic Acid is found in gall-nuts, bark of trees, and in all those vegetables called astringents.

Succinic Acid is obtained from amber, and is therefore called also acid of amber. Amber is a bituminous substance of a yellow colour, which is found chiefly on the sea-coast of Prussia. It takes a fine polish, and is used for various ornaments. It is strongly electrical

Suberic Acid exists in cork. It reddens vegetable blues, and has the peculiar property of turning the blue solution of indigo in sulphuric acid, to green.

Phosphorous Acid. When phosphorous is burnt slowly, and does not become completely saturated with oxygen, it forms phosphorous acid. Its salts are the phosphites.

Phosphoric Acid is phosphorus saturated with oxygen. This acid is obtained from bones, which are composed of phosphate of lime, and gelatine. It may also be obtained by the rapid combustion of phosphorus in oxygen gas.

Bombic Acid is obtained from the silkworm. It is very little known.

Pyroligneous Acid, obtained by distillation from wood, is sometimes called wood vinegar. This acid is said to preserve animal food for any length of time. The whole carcase of a sheep being immersed in it, was found, upon examination many months afterwards, to be perfectly free from any appearance of putrefaction. A leg of mutton, declared unsaleable by the butchers, being immersed in the pyroligneous acid, was, after a twelvemonth, perfectly sweet, and likely, from its appearance, to continue so many years.

Dr. Jorg, professor of Leipsic, has made many successful experiments of the same nature. He has entirely recovered several anatomical preparations from incipient corruption, by pouring this acid over them. With the oil which is produced from wood by distillation in the dry manner, he has moistened pieces of flesh already advanced in decay; and, notwithstanding the heat of the weather, soon made them as dry and firm as flesh can be rendered by being smoked in the smoking-room. All traces of corruption vanish at once when the vinegar of wood, or the oil of wood, is applied to the meat with a brush. The professor has also begun to prepare mummies of animals, and has no doubt of success. He promises great advantages to anatomy, domestic economy and even to medicine, from this discovery, for the remedy seems very fit to be applied internally and externally in many disorders.

It is made in the large way at an establishment at Battersea, of one uniform strength of 50 degrees, by the new excise autometer. This acid is pronounced to be pure acetous acid, perfectly free from sulphuric and all other mineral acids, and from mucilaginous, earthy, and metallic impurities. It is therefore, when diluted, perfectly wholesome with food, and may be used for all the purposes of vinegar.

The pyroligneous acid admits of being diluted with seven parts of water, which will reduce it to the strength of common distilled vinegar: it is then well qualified for pickling vegetables and fish: the latter, particularly, is found to be preserved longer with this vinegar, and to eat firmer and better than with any other. This acid is bright and colourless as water; but it readily takes any colour or flavour. It will keep for any length of time, in any climate, without losing its strength, or becoming ropy and thick, or mothery, as it is generally termed. At sea, it is particularly useful for the scurvy; and for all medical purposes, it answers the uses of the best distilled vinegar.

Sebacic Acid, called also the acid of fat, and obtained from the fat of animals, is concrete, and soluble in water. It is sour, and without odour.

Laccic Acid, lately discovered in a substance called white lac, is formed by certain insects of the coccus tribe.

Lactic Acid is found in the whey of milk. It is concrete, and liquefies in the air. It is sour, and oxidates the metals.

Saccho-Lactic Acid, discovered by Scheele, who obtained it by treating sugar of milk with nitric acid: it is also obtained by treating gum-arabic with nitrous acid.

Uric Acid, also called lithic acid, is found in urinary calculi, and in human urine.

Prussic Acid is produced by exposing the horns, hoofs, and dried blood of animals, with an equal quantity of fixed alkali, to a red heat. This acid, united to iron, forms that beautiful pigment called Prussian blue. From this salt the acid is frequently obtained, this being the least expensive mode. The pure acid is, perhaps, the most intense poison ever known: a glass rod dipped in it, was inserted in the mouth of a dog, who fell dead, as if struck by lightning, the instant it touched the poor animal's palate. The dog had been a remarkably strong one.

ACLOWA, a plant used by the natives of Guinea to cure the itch. The ACOUCROBA is famous among them for its cure of the small-pox, which is administered in an infusion of wine.

ACONITUM, common blue monk's-hood; every part of the fresh plant is strongly poisonous; the root most so. It is used in medicine.

ACORN, the fruit of the oak; upon which both man and beast may live.

ACORUS, in Botany, sweet rush; generally looked upon as a carminative and stomachic medicine: in Natural History, blue coral, which grows in form of a tree on the coast of Benin, in Africa.

ACOUSTICS is the science which treats of the nature, phenomena, and laws, of the sense of sound. It extends to the theory of musical concord and harmony, and is, therefore, a valuable and interesting science. Sound is considered as arising from vibrations in the air, communicated to it by vibrations of the sounding body, acting in pulsations, or concentric waves, like the surface of water when a stone is thrown into it. A sonorous body, whilst sounding, is unquestionably in a state of vibration, and the air, by similar vibrations, communicates and propagates these vibrations. The principal causes of the variety of sounds, are: *First,* The greater or less frequency of the vibration. *Secondly,* The quantity or force of the vibrating materials. And, *Thirdly,* The greater or less simplicity of the sounds. Hence arise the height, the strength, and the modification, of sounds. The vibrations of a sounding body continue for a longer or shorter time, according as the body is more or less elastic, or as it is thicker or thinner.

Of the Velocity of Sound. By experiments, we know that sound travels 1142 feet in a second, or 13 miles a minute: water accelerates its velocity; and all sounds travel at the same rate; the softest whisper flies with the speed of the loudest thunder. The velocity of sound is to that of a brisk wind as fifty to one.

The velocity of sound has been applied to the measurement of distances.

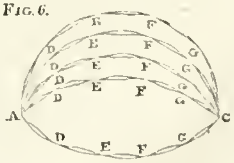
A ship at sea in distress fires a gun, the light of which is seen on shore 20 seconds before the report is heard, therefore it is known to be at the distance of 20 times 1142 feet, or little more than 4½ miles. I see a vivid flash of lightning; and if in three seconds I hear a tremendous clap of thunder, I instantly know that the thunder cloud is only two-thirds of a mile distant. I should therefore retire instantly from any exposed situation. The pulse of a healthy person beats about 76 times in a minute; if, therefore, between the flash of lightning and the thunder I can feel 1, 2, 3, 4, &c. beats of my pulse, I know the cloud is 900, 1800, 2700, 3600 feet from me.

Smooth and clear sounds proceed from bodies that are homogeneous, and of an uniform figure: harsh and rough, or obtuse sounds, from irregular bodies, or such as are made of mixed matter. The strength of sounds is greatest in cold and dense air; and least in that which is warm and rarefied. And under an exhausted receiver, a bell gives no sound. Every point against which the pulses of sound strike, becomes a centre from which a new series of pulses are propagated in every direction. Hence the extraordinary echoes we sometimes hear.

Of reverberated Sounds. Sounds, like light, after it has been reflected from several places, may be collected into one point, as into a focus; it will there be more audible than in any other part, even than at the place whence it proceeded. On this principle, the

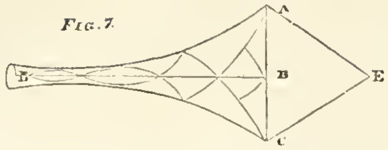
Whispering Gallery, fig. 6, is constructed. Its form is that of a concave hemisphere, as ADC, and if a low sound be uttered at A, the vibrations expanding themselves every way, impinge on the points D, D, D, D, E, E, &c. and from thence to the points F, G, till they all meet in C, where the sound, being collected as in a focus, will be perfectly well heard. Upon this principle, the whispering gallery of St. Paul's Cathedral, London, is constructed.

FIG. 6.



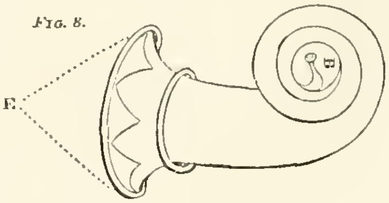
The Speaking Trumpet is constructed on the principle of the *reflection* of sounds. Thus, the voice discharged

Fig. 7.



at B, fig. 7, is confined within the tube, and the vibrations striking against its hollow sides, are reflected back to the angle of incidence, and fall into the direction of the vibrations that proceed straight forwards. The whole of the vibrations are thus collected at E, and if the ear be situated at or near that spot, the sound is prodigiously increased. The reflected rays fall without, the rays of incidence within, the trumpet. Every one knows the utility of speaking or hearing trumpets, fig. 8, to deaf persons. The reason is obvious; the speaker's voice at the point E, is reflected to the larger end of the trumpet, and passes by the rays of incidence into the ear at B.

Fig. 8.

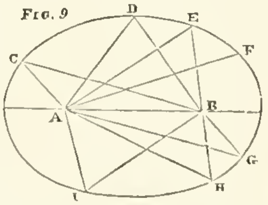


Of Echoes.—An echo is a reflection of sound striking against some object, as an image is reflected in the glass: but it has been disputed what are the proper qualities in a body for thus reflecting sounds. It is in general known, that caverns, grottoes, mountains, and ruined buildings, return this reflection of sound.

We have heard of a very extraordinary echo, at a ruined fortress near Louvain, in Flanders. If a person sung, he heard only his own voice, without any repetition: on the contrary, those who stood at some distance heard the echo, but not the voice; but then they heard it with surprising variations, sometimes louder, sometimes softer, now more near, then more distant. There is an account in the *Memoirs of the French Academy*, of a similar echo near Rouen.

Philosophical Principle of an Echo. Fig. 9.—It has been already observed, that every point against which the pulses of sound strike, becomes the centre of a new series of pulses, and sound describes equal distances in equal times; therefore, when any sound is propagated from a centre, and its pulses strike against a variety of obstacles, if the sum of the right lines drawn from that point to each of the obstacles, and from each obstacle to a second point, be equal, then will the latter be a point in which an echo will be heard. Thus, let A be the point from which the sound is propagated in all directions, and let the pulses strike against the obstacles C, D, E, F, G, H, I, &c. each of these points becomes a new centre of pulses by the first principle, and therefore from each of them one series of pulses will pass through the point B. Now if the several sums of the right lines AC+CB+, AD+DB, AE+EB, AG+GB, AH+HB, AI+IB, &c. be all equal to each other, it is obvious that the pulses propagated from A to these points, and again from these points to B, will arrive at B at the same instant, according to the second principle; and therefore, if the hearer be in that point, his ear will at the same instant be struck by all these pulses.

Fig. 9



Now it appears from experiment, that the ear of an exercised musician can only distinguish such sounds as follow one another at the rate of 9 or 10 in a second, or any slower rate; and therefore for a distinct perception of the directed and reflected sound, there should intervene the interval of about $\frac{1}{9}$ of a second; but in this time sound describes $\frac{1142}{9}$ or 127 feet nearly. And therefore, unless the sum of the lines drawn from each of the obstacles of the points A and B, exceeds the interval AB by 127 feet, no echo will be heard at B. Since the several sums of the lines drawn from the obstacles to the points A and B are of the same magnitude, it appears that the curve passing through all the points C, D, E, F, G, H, I, &c. will be an *ellipse*. Hence, all the points of the obstacles which produce an echo, must lie in the surface of the oblong spheroid, generated by the revolution of this ellipse round its major axis.

Different Echoes philosophically accounted for.—As there may be several spheroids of different magnitudes, so there may be several different echoes, of the same original sound. And as there may happen to be a greater number of reflecting points in the surface of an exterior spheroid than that of an interior, a second or a third echo may be much more powerful than the first, provided that the superior number of reflecting points, that is, the superior number of reflected pulses propagated to the ear, be more than sufficient to compensate for the decay of sound, which arises from its being propagated through a greater space. This is finely illustrated in the celebrated echoes at the lake of Killarney in Ireland, where the first return of the sound is greatly inferior to those which succeed it immediately.

From what has been laid down, it appears, that, for the most powerful echo, the sounding body should be in one focus of the ellipse, which is the section of the echoing spheroid, and the hearer in the other. However, an echo may be heard in other situations, but not so favourably, as such a number of reflected pulses may arrive at the same time at the ear, as may be sufficient to excite a distinct perception. Thus a person often hears the echo of his own voice; but for this purpose he should stand at least 63 or 64 feet from the reflecting obstacle, according to what has been said before.

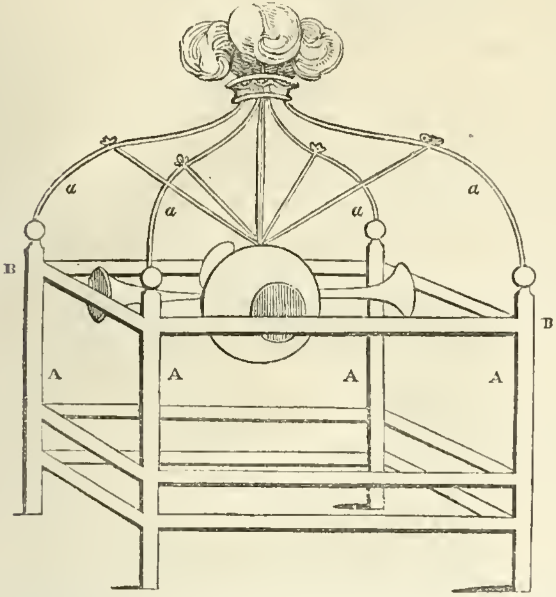
At the common rate of speaking, we pronounce not above three syllables and a half, that is, seven half-syllables, in a second, therefore, that the echo may return just as soon as three syllables are expressed, twice the distance of the speaker from the reflecting object must be equal to 1000 feet; for as sound describes 1142 feet in a second, $\frac{7}{8}$ of that space, that is, 1000 feet nearly, will be described, while six half, or three whole syllables are pronounced; that is, the speaker must stand 500 feet from the obstacle. And in general, the distance of the speaker from the echoing surface, for any number of syllables, must be equal to the seventh part of the product of 1142 feet multiplied by that number.

In churches, we never hear a distinct echo of the voice, but a confused sound when the speaker utters his words too rapidly; because the greatest difference between the direct and reflected courses of such a number of pulses as would produce a distinct sound, is never in any church equal to 127 feet, the limit of echoes. But though the first reflected pulses may produce no echo, both on account of their being too few in number, and too rapid in their return to the ear; yet it is evident, that the reflecting surface may be so formed, as that the pulses which come to the ear after two reflections or more, may, after having described 127 feet or more, arrive at the ear in sufficient numbers; and also so nearly at the same instant of time, as to produce an echo, although the distance of the reflecting surface from the ear be less than the limit of echoes. For example, as you enter a small grotto, on the banks of the Dinan, about 2 miles from Castlecombe, in the county of Kilkenny, and continue speaking aloud, no return of voice is perceived; but on arriving at a certain point in the cave, about 14 or 15 feet from the reflecting surface, a very distinct echo is heard. This echo is produced solely by those pulses of voice, which, after being reflected several times from one side of the grotto to the other, (as you observed in the hollow tube of the trumpet,) and having run over a greater space than 127 feet, arrive at the ear in considerable numbers, and no more distant from each other, in point of time, than the ninth part of a second.

The Invisible Girl, a deception connected with the conveyance of sound, is an acoustic experiment, which may thus be scientifically and familiarly explained.

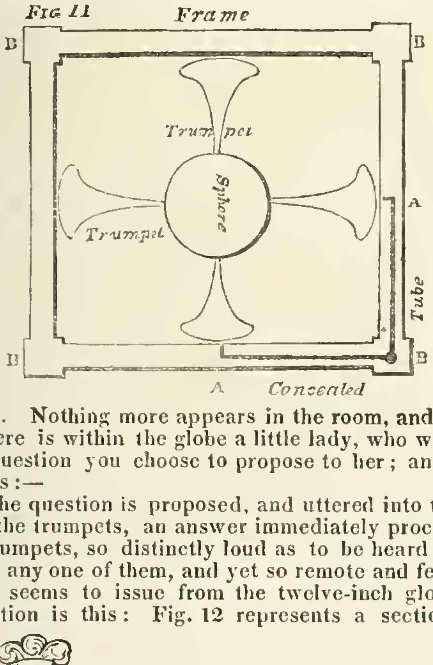
In the centre of a large room is placed an apparatus, as fig. 10, with a railing surrounding it, about five feet high, and as many wide. A, A, A, A, are the posts united by the cross-rail B, B, near the top, and by two more similar rails near the bottom. The plume and globe are supported by four stout brass wires. The globe, or ball of copper, is about 12 inches diameter; and the ribbons which suspend it to the bent wires seem to cut off all communication with the frame.

FIG. 10. Apparatus of the Invisible Girl.



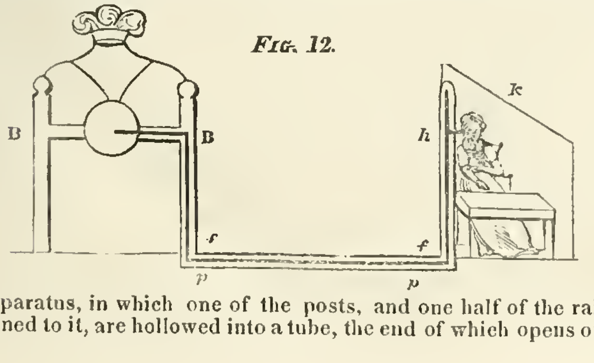
Round this ball are placed four trumpets, at right angles to each other, as shewn in fig. 11, having their mouths opening externally. Nothing more appears in the room, and it is pretended there is within the globe a little lady, who will answer you any question you choose to propose to her; and the process is this:—

FIG 11



When the question is proposed, and uttered into the mouth of one of the trumpets, an answer immediately proceeds from all the trumpets, so distinctly loud as to be heard by an ear applied to any one of them, and yet so remote and feeble, that it actually seems to issue from the twelve-inch globe. But the deception is this: Fig. 12 represents a section of the apparatus, in which one of the posts, and one half of the rail joined to it, are hollowed into a tube, the end of which opens on the inside of the rail opposite the centre of the trumpet on that side. This hole is concealed by mouldings, &c.; the tube communicates with a tin pipe *p*, *p*, half an inch diameter, concealed below the floor of the room *f*, *f*, and passing up the wall to a large deal case, *k*, almost similar to an inverted funnel, and large enough to contain the *confederate* or *invisible girl*, and a piano on which she plays. A small hole, closed with glass, is left through the funnel and side-wall of the room, as at *h*, which allows her to comment on what is passing among the company. Thus, when any question is asked at one of the trumpets, the sound is conveyed through the communicating tubes into the funnel-shaped case, so as to be heard by the confederate, who then gives the answer, which in like manner is conveyed through the tube, below the floor, to one of the trumpets, and is heard either from that, or any of the rest.

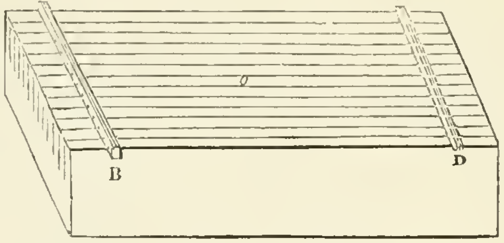
FIG. 12.



PHILOSOPHICAL ACOUSTIC EXPERIMENTS.

1. *The Æolian Harp*, fig. 13, is so named from Æolus, the heathen deity of winds, as it produces its wild and often exquisite strains, merely by the action of the wind. It is thus constructed:—Let a box be made of as thin deal as possible, of the exact length answering to the width of the window in which it is intended to be placed, five or six inches deep, and seven or eight inches wide; let there be glued upon it two pieces of wainscot, A B, C D, about half an inch high, and a quarter of an inch thick, to serve as bridges for the strings; and, within side, at each end, glue two pieces of beech, about an inch square, of length equal to the width of the box, which are to sustain the pegs: into these fix as many pins, such as are used in a harpsichord, as there are to be strings in the instrument, 7, 10, or 15,—half at one end and half at the other, at equal distances: it now remains to string it with small catgut, or blue first fiddle-strings, fixing one end to a small brass pin, and twisting the other round the opposite pin. When these strings are tuned to one and the same note, and the instrument placed with the strings outward in the window to which it is fitted, it will, provided the air blows on that window, give a charming sound like a distant choir, increasing or decreasing according to the strength of the wind. The figure represents an instrument with ten chords; some musicians direct the two extreme chords to be two octaves below the central ones. And here it may be proper to remark, that two strings, of equal length, tension, and thickness, by performing their vibrations together, will sound the same note, or be in unison. Two pipes of the same length and diameter will agree in the same manner. Large instruments and long strings produce grave or deep tones; small instruments and short strings produce acute and high tones.—In the case of the strings, the air is struck by the body, and the sound is excited by the vibrations: in that of the pipes, the body is struck by the air, but, as action and re-action are equal, the effect is the same. Let a musical string of any length be divided into two equal parts by a bridge in the middle; and the sound of each half is eight notes, or an octave, higher than the tone of the whole string. Organ pipes produce grave or acute tones in proportion to their length and size. It is the shortest string of a harpsichord which yields the highest notes.

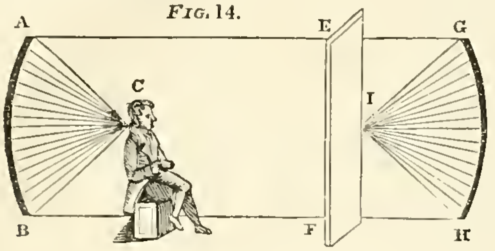
FIG. 13.



2. *The Conversing Statue*, fig. 14, consists of a concave mirror, about 2 feet diameter, as AB, placed in a perpendicular direction; the focus of the mirror being from 15 to 18 inches from the surface. At the distance of 5 or 6 feet is a partition, with an opening E F, of the same size with the mirror;

against this opening place a picture painted in water colours, on a thin cloth, that the sound may easily pass through it.

Fig. 14.



The more effectually to conceal the cause of this illusion, the mirror A B, may be fixed in the wainscot, and a gauze, or any other thin covering, thrown over it, as that will not in the least prevent the sound from being reflected. An experiment of this kind may be performed in a field, or garden, between two hedges, in one of which the mirror A B may be placed, and in the other an opening artfully contrived. Behind the partition, at the distance of two or three feet, place another mirror, G H, of the same size as the former, and let it be diametrically opposite to it. Both the mirrors here used may be of tin, or gilt pasteboard; this experiment not requiring such as are very accurate. At the point C, let there be placed the figure of a man seated on a pedestal, and let his ear be placed exactly in the focus of the first mirror; his lower jaw must be made to open by a wire, and shut by a spring; and there may be another wire to move the eyes: these wires must pass through the figure, go under the floor, and come up behind the partition. Let a person, properly instructed, be placed behind the partition near the mirror. You then propose to any one to speak softly to the statue, by putting his mouth to the ear of it, assuring him that it will answer instantly. You then give the signal to the person behind the partition, who, by placing his ear to the focus I, of the mirror G H, will hear distinctly what the other said; and moving the jaws and eyes of the statue by the wires, will return an answer directly, which will, in like manner, be directly heard by the first speaker.

3. *The Communicative Busts*, fig. 15, two plaster-of-paris figures, placed on pedestals, on the opposite sides of a room, form an elegant and amusing illusion. A tube, one inch diameter, passes from one head to the other, through the pedestals, under the floor, and the whole is so disposed that no appearance of communication is visible. But when a stranger speaks quite low into the ear of one bust, the words are reverberated through the tube, and are very distinctly heard issuing from the mouth of the other bust. Two tubes, one from the ear to the mouth of each head, afford the enjoyment of mutual converse to two persons, while others, standing in the middle of the room, shall not hear what is spoken.—The telegraphs in the walls built by the Romans, were flues, by means of which orders were given from one station to another, on the foregoing principle.

Fig. 15.

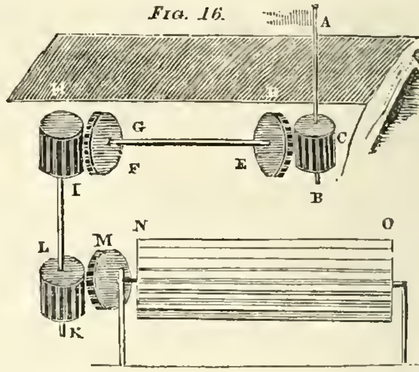
4. *The Oracular Head*, upon the principle just laid down, may have also a series of wires to move the eyes, lips, &c. and give the image all the appearance of animation while it discourses. Such machines are exhibited at fairs, and sometimes in London.

5. *The Solar Sonata*, composed of dials, spring clocks, and glass tubes, is as complex a piece of mechanism as an organ, and of no other utility than to shew, that the rays of the sun, rectifying spirits in a glass tube, can let off a trigger, and so set a musical clock to play.

6. *The Automaton Harpsichord*, is a common harpsichord, put in motion by means of a smoke-jack; the wires which communicate with the keys of the instrument, being concealed from the public. This machinery may be applied to any other keyed instrument, as well as to chimes, and to many other purposes where a regular continued motion is required. An instrument of this sort may be considered as a perpetual motion, according to the vulgar acceptation of the term, for it will never cease going till the fire be extinguished, or some parts of the machinery be worn out.

7. *The Ventosal Symphony*, fig. 16, may be erected at the top of a summer-house, or other building: let there be fixed a vane A B, on which is the pinion C, that takes the toothed-wheel D, fixed on the axis E F, which at its other end carries the wheel G, that takes the pinion H. All these wheels and pinions are to be between the roof and ceiling of the building. The pinion H is fixed to the perpendicular axis I K, which goes down very near the wall of the room, and may be covered after the same manner as bell wires. At the lower end of the axis I K, there is a small pinion L, that takes the wheel M, fixed on the axis of the great wheel N O. In this wheel there must be placed a great number of stops, corresponding to the tunes to be played, and these stops are to be moveable, that the tunes may be altered at pleasure. Against this wheel there must hang 12 small bells, answering to the notes of the gamut. Therefore, as the wheel turns round, the stops striking against the bells, play the several tunes. But there should be a fly to the great wheel, to regulate or equalize its motions, when the wind is strong. The wheel N O may be enclosed in a case; and of the several bells, one may be a tenor, another a treble, a third bass, in order to play different tunes, according to the size of the wheel: and the bells being small, their chimes will be the more pleasing, if they are cast of silver alone; or glasses may be used, and so disposed as to move freely at the sound of the stops. This machinery may be applied to a barrel-organ, and many other uses.

Fig. 16.



ACRE, the universal measure of land, containing 4 square roods; each rood being 40 perches, or 16½ feet. In some places, the perch or pole runs from 16½ to 28 feet. The acre is divided into 10 square chains, of 22 yards each, *i. e.* 4840 square yards. The acre in Scotland contains 6 square roods; one rood contains 40 square falls; one square fall 36 square ells; one square ell 9 feet square, and 73 square inches; one square foot 144 square inches. The Scots acre contains also 10 square chains: the chain 24 ells, of 100 links, each $8\frac{928}{1000}$ inches; and therefore one square chain contains 10,000 square links. The French acre, *arpent*, contains 1¼ English acre, or 54,450 square feet.

ACROMION, in Anatomy, the upper part of the shoulder blade.

ACRONICAL, in Astronomy, the rising or setting of a star when the sun is setting.

ACROSPIRED, in malt-making, is the grains shooting both at the root and blade end.

ACROSTERIA, in Architecture, small pedestals usually without bases, serving to support statues. Also the sharp pinnacles placed in ranges about flat buildings, with rails and balusters.

ACROSTICHUM, in Botany, a genus of plants, in the class Cryptogamia, order Filices.

ACT of Parliament. A law passed by the two houses of parliament, and sanctioned by the royal signature.

ACTS of the Apostles, one of the sacred books of the New Testament, written by St. Luke, about the 64th year of the

Christian era. Among the spurious Acts of the Apostles, we may reckon, 1. The Acts of Abdias, bishop of Babylon; 2, the Acts of St. Peter; 3, the Acts of St. Paul; 4, of St. John; 5, of St. Andrew; 6, of St. Thomas; 7, of St. Philip; and, 8, of St. Matthias.

ACTÆA, a plant producing bane-berries, whose juice gives a fine deep black, if fixed with alum.

ACTION, in Painting and Sculpture, is the attitude or position of the several parts of the face, body, and limbs, to shew that the subjects are really actuated by the passions.

ACULER, in the Manege, the motion of a horse, when, in working upon volts, he goes not forward enough at each movement, so that his shoulders are not advanced enough, and his croup comes too near the centre of the volt.

ACUTE ANGLE, an angle less than a right angle. *Acute-angled*, Δ, a triangle having all its angles acute. *Acute-angled cone*, a right cone whose axis makes a right angle with its side. *Acute tone*, in Music, a tone high or sharp in comparison of some other tone. *Acute*, in diseases, such as come rapidly to a crisis.

AD VALOREM, in Commerce, according to value.

ADAGIO, in Music, softly, leisurely.

ADAMI POMUM, a protuberance in the forepart of the throat, formed by the *os hycides*, and vulgarly attributed to a piece of the forbidden apple that stuck in our great progenitor's throat.

ADANSONIA, a plant, the Ethiopian sour-gourd.

ADATAIS, a very fine muslin of India.

ADDEPHAGIA, the disease of gluttony.

ADDER, the viper. *Adder-stung;* for the cure of such bites, some use ointment made of dragon's blood, with a little barley meal and the whites of eggs. *Adder wort*, the same as snakeweed.

ADDITION, the joining or uniting of two or more things together; or the finding of one quantity equal to the sum of any number of other things taken together.

ADDITION, in Arithmetic, is the first of the four fundamental rules of that science; and consists in finding a number equal to several others taken together; which number is generally called the *sum*. Addition is either simple or compound; the first relates to quantities which are all of the same kind or denomination; and the latter, to quantities of different denominations.

Simple ADDITION, is the method of collecting several numbers of the same denomination into one sum.—*Rule* 1. Place the numbers under each other, so that units may stand under units, tens under tens, and hundreds under hundreds, and so on; drawing a line below them. 2. Add up the figures in the row of units, and find how many tens are contained in their sum. 3. Set down what remains above the tens, or, if nothing remains, a cipher; and carry as many units as there are tens, to the next row. 4. Add up the second row, together with the number carried, in the same manner as the first; and proceed thus till the whole is finished.

Ex. 1.		*Ex.* 2.
7468		2468
3417		1357
5432		9135
6847		2468
4132		7523
1489		6814
28785	Sums	29765

Proof of Addition. Cast up the several lines a second time, omitting one of them; and, finally, add the line thus omitted to the sum of the other quantities; and if in this manner the same result is obtained as in the first operation, it is highly probable that the work is right. Other methods of proof may be seen in most authors on this subject.

Compound ADDITION, is the method of collecting several quantities of different denominations into one sum.—*Rule* 1. Place the quantities so that those of the same denominations stand directly under each other; and draw a line below them. 2. Add up the figures in the lowest denomination, and find how many units of the next higher denomination are contained in their sum. 3. Write down the remainder, and carry these units to the next higher denomination; which add up in the same manner as before: and thus proceed through all the different denominations to the highest; and this sum, together with the several remainders, will give the answer required.

	£.	*s.*	*d.*		Yds.	Ft.	In.
Example 1.	84	13	4	*Example* 2.	17	1	11
	64	9	11½		16	2	9½
	36	14	9½		13	1	7¼
	17	15	7¾		14	0	6¾
	19	13	6¼		20	0	0
	25	10	6		18	2	9
	59	15	8		16	1	7
	42	12	9		19	0	5
	351	6	2	Sums	136	2	7½

The method of proof is the same as in the former rule.

ADDITION *of Fractions*, is the adding into one sum several fractions of the same, or of different denominations.—*Rule* 1. If the fractions are of different denominations, they must be first reduced to the same denomination. 2. Reduce all mixed numbers to improper fractions; and all fractions, having different denominators, to the same denominator. 3. Add all the numerators into one sum; which, placed over the common denominator, will be the answer required.

Examples.—1. Add together the fraction $\frac{1}{2}$, $\frac{1}{3}$, and $\frac{1}{7}$.

First, $\frac{1}{2}=\frac{35}{70}$; $\frac{1}{3}=\frac{14}{70}$; $\frac{1}{7}=\frac{10}{70}$: then, $\frac{35}{70}+\frac{14}{70}+\frac{10}{70}=\frac{59}{70}$.

2. Required the sum of $\frac{2}{3}$ of a shilling, $\frac{3}{4}$ of a guinea, and $\frac{7}{8}$ of a pound.

$\frac{3}{4}$ of a guinea $=\frac{63}{4}$ of a shilling, $\frac{7}{8}$ of a pound $=\frac{35}{2}$ of a shilling.

Therefore, $\frac{2}{3}+\frac{63}{4}+\frac{35}{2}=\frac{8}{12}+\frac{189}{12}+\frac{210}{12}=\frac{407}{12}=33s.\ 11d.$ $=$ £1. 13*s.* 11*d.*—For the method of reducing the fractions, see REDUCTION.

ADDITION *of Decimals*, is finding the sum of several quantities, consisting partly of integers and partly of decimals, or of decimals only.—*Rule* 1. Arrange all the quantities, so that the several decimal points may fall in a line directly under each other. 2. Add up the several lines as in simple addition, and place the decimal point in the result exactly under those in the numbers proposed, and it will be the sum required.

Example 1.		*Ex.* 2.
34·17		·1176
19·143		·1344
167·13		744
143·5		·1468
363·943	Sums.	1·1428

ADDITION *of Circulating Decimals*, is the finding the sum of any number of circulating decimals.—*Rule* 1. Reduce all the decimals to their equivalent fractions; and the sum of these will be the fractions required.—*Rule* 2. Carry on the repetends till they become conterminous; that is, till they all begin their periods of circulation in the same line, and let also the circulation of each be carried two figures beyond this place: then add as above, but do not set any figure down in the first two places: carry their proper number, however, to the conterminous period, and the result will give the true period of circulation in the sum required.

Example. Add $3{\cdot}\dot{6}$; $78{\cdot}3\dot{4}7\dot{6}$; $42\dot{8}\dot{4}$; $15{\cdot}\dot{5}$ together.

$$\begin{array}{rcl|l} 3{\cdot}\dot{6} & = & 3{\cdot}\dot{6}\dot{6}\dot{6}\dot{6}\dot{6}\dot{6}\dot{6} & 66 \\ 78{\cdot}3476 & = & 78{\cdot}3476476 & 47 \\ 42{\cdot}\dot{8}4 & = & 42{\cdot}84\dot{8}4\dot{8}48\dot{8} & 48 \\ 15{\cdot}\dot{5} & = & 15{\cdot}500000\dot{0} & 00 \\ \hline \text{The Sum......} & & 140{\cdot}3627991 & \end{array}$$

ADDITION, in Algebra, is finding the sum of several algebraic quantities, and connecting those quantities by their proper signs.

Case 1.—When the quantities have like signs, add all the co-efficients, and annex the common letter or letters, and prefix the common sign.

Example.

$$\begin{array}{r} 6\,a \\ 8\,a \\ 10\,a \\ 18\,a \\ \hline 42\,a \end{array} \qquad \begin{array}{rcrcr} 3\,a & + & 2\,x & - & 46 \\ 2\,a & + & 3\,x & - & 36 \\ 12\,a & + & 17\,x & - & 186 \\ a & + & x & - & 6 \\ \hline 18\,a & + & 23\,x & - & 274 \end{array}$$

Case 2.—When the quantities are alike, but have unlike signs, collect the positive co-efficients into one sum, and the negative ones into another. From the greater of these sums subtract the less, and to the remainder prefix the sign of the greater, and annex the common letters. If the aggregate of the positive terms be equal to that of the negative ones, their sums will be = 0.

Examples.

$$\begin{array}{r|r}
1. & 2. \\
-3x+4 & -7ab+3bc-xy \\
+x-5 & -ab+2bc+4xy \\
-5x+1 & 3ab-bc+2xy \\
+2x-4 & -2ab+4bc-3xy \\
-4x+13 & 5ab-8bc+xy \\
\hline
-9x+9 & -2ab \quad * \quad +3xy
\end{array}$$

The manner in which we generally calculate a person's property, is an apt illustration of this rule. We denote what a man really possesses by positive numbers, using the sign + ; whereas his debts are represented by negative numbers, or the sign —, affecting those numbers. When it is said of any one that he has 100 crowns, but owes 50, his real possession amounts to 100 — 50, or, which is the same thing + 100 — 50, that is to say, 50. And if he has in possession 20 crowns, but owes 20, his real possession amounts to 20 — 20, or + 20 — 20 = 0. He has nothing; but owes nothing. But, on the other hand, if he owes 70 crowns, and has in his possession only 40, his real property would be expressed thus — 70 + 40. Here his debt is represented by the negative number — 70, while his real possession is represented by the positive number + 40. He has 30 crowns less than nothing; and we might express the state of his finances — 30; for if any one were to make him a present of 30 crowns to pay this debt, or — 30, he would only be at the point nothing (0), though really richer than when — 30 stood against his future prospects and exertions. Debts, or money owing, are therefore as much real sums of money as credits, and the sign +, or —, *governs* the quantity or number that follows it.—In the language of Algebra, a and b may stand for any two numbers whatever, and therefore, $a + b$ stands for a made more by b. Again, $a - b$ stands for a made less by b; that is, for the difference of a and b, (where b is supposed less than a.) Now, by the rule of Case 2, $a + b$ and $a - b$, added together, make twice a ($2a$); therefore we derive this *Theorem:* If the sum and difference of any two numbers be added together, the whole will be twice the greater number; for if $a + b$ be added to $a - b$, the sum is $2a$.

ADDITION *of Algebraic Fractions*, is finding the sum of any number of fractions expressed by means of intermediate letters.—*Rule.* Reduce all the given fractions to a common denominator, and then add the numerators together for the sum required.

Example 1. Add together $\frac{5a}{6b^2} + \frac{3a^2}{4b} + \frac{5c}{12b^3}$

$$\frac{5a}{6b^2} = \frac{10ab}{12b^3};\ \frac{3a^2}{4b} = \frac{9a^2b^2}{12b^3};\ \frac{5c}{12b^3} = \frac{5c}{12b^3}$$

$$\frac{10ab}{12b^3} + \frac{9a^2b^2}{12b^3} + \frac{5c}{12b^3} = \frac{10ab + 9a^2b^2 + 5c}{12b^3}.$$

Example 2. Thus also we find, $\frac{7x}{11y} + \frac{4x}{3y} = \frac{21x}{33y} + \frac{44x}{33y} = \frac{65x}{33y}$

Example 3. And, $\frac{7x+4y}{3ab} + \frac{5x-3y}{abc} = \frac{7cx+4cy}{3abc} \times$

$$\frac{15x-9y}{3abc} = \frac{7cx+15x+4cy-9y}{3abc} = \frac{(7c+15)x+(4c-9)y}{3abc}.$$

ADDITION *of Surds*, is the finding the sum of any number of surd expressions, which are inexpressible in rational numbers. —*Rule.* Reduce all the given quantities to their simple form; then add the co-efficients of the equal radicals for the sum required. Thus,

$$\sqrt{8} + \sqrt{18} = 2\sqrt{2} + 3\sqrt{2} = 5\sqrt{2}$$
$$\sqrt{12} + \sqrt{27} = 2\sqrt{3} + 3\sqrt{3} = 5\sqrt{3}$$
$$\sqrt[3]{108a^4} + \sqrt[3]{32a} = 3a\sqrt[3]{4a} + 2\sqrt[3]{4a} = (3a \times 2)\sqrt[3]{4a}.$$

Note. When the quantities are reduced to their lowest terms, or simplest form, and have different radicals, they can only be added together by means of the sign + placed between them. Thus, $\sqrt{18} + \sqrt{108} = \sqrt{2} + 6\sqrt{3}$, cannot be reduced to a simpler form than that above; and the same with various others.

ADDITIONS, in Heraldry, are things added to arms as marks of honour; as bordure, quarter, canton, gyron, pile, &c.

ADENANTHERA, in Botany, bastard flower-fence.

ADHESION, in Mechanical philosophy, the same with cohesion, denotes that attraction which takes place between bodies, only when they are at very small distances from each other. *See* COHESION.

ADIT, a passage, or entrance. The *adits* of mines are those holes or apertures by which they are entered, or by which the ores and waters are carried away: and the *adit* is sometimes merely an air-shaft.

ADJUDICATION, in Scots law, the name of the action by which a creditor attaches the heritable estate of his debtor.

ADMINISTRATOR, he to whom the ordinary commits the administration of the goods of a person deceased, in default of an executor.

ADMIRAL, a great officer of the navy; the commander-in-chief of a fleet.

ADORATION, the act of performing the religious worship of the Almighty.

ADVANCED *Ditch*, in Fortification, that trench which surrounds the glacis or esplanade of a place. *Advanced guard*, the first line of an army; usually a party of horse stationed before the main guard.

ADYTUM, the most secret part of a heathen temple.

ÆGILOPS, the name of a tumor that sometimes gathers in the great angle of the eye, either with or without inflammation. The method of cure is the same as that of the ophthalmia; but before it has reached the lachrymal passages, it is managed like other ulcers. If the ægilops be neglected, it bursts, and degenerates into a fistula, which eats into the bone.

ÆGIPHILA, in Botany, goat's friend.

ÆGOPODIUM, small wild angelica, goat wort, or goat's foot.

ÆOLUS, in Mechanics, a small portable machine, for refreshing and changing the air in rooms, adapted in its dimensions to supply the place of a square of glass in a sash window; and executed in so small a compass, as to project but a little way from the sash; and in so neat a manner, as to be an elegant ornament to the place where it is fixed. It works without the least noise, requires no attendance, and occasions neither trouble nor expense to keep it in order. It throws in only such a quantity of air as is agreeable; and leaves off working of itself whenever the door or window is opened.

ÆRA, in Chronology, or Epocha, is a certain fixed point of time, made famous by some remarkable event, from which, as from a root, the ensuing years are numbered or computed.

1. The *Æra of the Creation*, according to the Jewish calculation, is the year of the Julian period 953, answering to the year 3761 before Christ, and commencing on the 7th of October. Archbishop Usher fixed the creation of the world 4004 years before the birth of Christ.

2. *The Æra of the Olympiads.* This method of computation had its name from the Olympic games, which were celebrated every 4th year, near the city of Olympia, in Peloponnesus. The first Olympiad commenced, according to some chronologers, in the year 3938 of the Julian period; the year from the creation 3174, the year before Christ 774, and 24 years, (as some will have it 23 years,) before the building of Rome. The Olympiads were also called *Anni Iphiti*, from *Iphitus*, who instituted, or at least renewed, the solemnity of the Olympic games. We do not find any computation by Olympiads after the 364th, which ended with the year of Christ 440, except that, in a charter of our king Ethelbert, the years of his reign are said to be reckoned by Olympiads. This method of reckoning was followed by the ancient Greeks.

3. *The Æra of the Building of Rome;* which took place A.M. (i. e. in the year of the world) 3197, and B. C. (before Christ, 752 or 753. This has also been called the *Varronian epocha*, being first introduced by Terentius Varro. The ancient Roman historians usually follow this epoch, which is referred to thus, A. U. C. (that is, *Anno Urbis Conditæ*, or the Year of Building the City.)

4. *The Æra of Seleucus* was followed by the Syro-Mace-

donians; Seleucus the Great having disused the æra of the Olympiads, and reckoned from the beginning of his own reign, which was twelve years after the death of Alexander. The æra of Seleucus commences with the retaking of Babylon by Seleucus in the year of the world 3692, and before Christ 312.

5. *The Æra of Dioclesian* was introduced in honour of the emperor of that name; it has also been called the *Æra of the Martyrs*, from the vast number of Christians who were put to death during the Dioclesian persecution. This æra commenced in the year of Christ 284, and was long followed in the west.

6. *The Vulgar* or *Christian Æra*, (or of A. D.) This was not fully settled till the year 527; when Dionysius Exiguus, a Roman abbot, fixed it to the 4713th year of the Julian period, which was *four* years too late. It is, however, now so generally received, that this gross error in calculation is disregarded.

7. *The Hegira*, or *Turkish Æra*, took its rise from the false prophet Mohammed's flight from Mecca to Medina, on Friday, July 16, A.D. 622. It is a lunar year, beginning with the new moon of that time, which is the reason of the regard for crescents in the East, where they rise on every mosque. In order to know in what year of the vulgar æra any given year of the Hegira falls, the student should reduce the lunar years into solar years, and add the number 622. Thus, the year 1221 of the Hegira corresponds with the year 1806 of the vulgar æra; it commenced on the 21st day of March, 1806, and terminated on the 11th of March, 1807.

8. *The Æra of the French Revolution.*—As this æra is constantly referred to, by French writers, during the period that France was under republican government, a few particulars concerning it may assist the reader's historical studies. The æra in question was substituted for the vulgar or Christian æra, in all public and civil instruments, by virtue of the decree, issued by the National Convention, on the 5th October, 1793. It commenced with the epocha of the foundation of the republic, *i. e.* on the 22d of September, 1792, of the vulgar æra; on the morning of which day the sun arrived at the true autumnal equinox, at 18 minutes and 30 seconds past nine o'clock. (Paris time.) In the new calendar, the months consisted of 30 days each, divided into three decades; with five intercalary days to complete the year. The names of the months were adapted to the climate of Paris, thus: *Vendemiaire*, or vintage month; *Brumaire*, or foggy month; *Frimaire*, or sleety month; *Nivose*, or snowy month; *Pluviose*, or rainy month; *Ventose*, or windy month; *Germinal*, or budding month; *Floreal*, or flowery month; *Prairial*, or meadow month; *Messidor*, or harvest month; *Thermidor*, or hot month; and *Fructidor*, or fruit month. This æra (the experiment of an infidel philosophy) was abolished by Buonaparte, and the Christian æra recommenced with 1806.

AERIAL, Perspective, is that which represents bodies diminished and weakened in proportion to their distance from the eye; but it relates principally to the colours of objects, which are less distinct the greater the distance at which they are viewed.

AEROLITHS, air-stones, a name given to those solid semi-metallic substances which fall from the atmosphere. The descent of such bodies had been long reported; but the fact was not considered authentic till within a few years: it is now so well established, that there is no longer any doubt on the subject, several cases having been attested by eye-witnesses of undeniable veracity. The larger stones have been seen as luminous bodies, moving with great velocities, descending in oblique directions, and frequently with a loud hissing noise, resembling that of a mortar-shell when projected from a piece of ordnance; they are sometimes surrounded with a flame, tapering off to a narrow stream at the hinder part, are heard to explode, and seen to fly in pieces. The velocity with which they strike the earth is very great, frequently penetrating to a considerable depth, and when taken up, have been, in some cases, found to be still hot, and bearing evident marks of recent fusion. Such falls have happened during a thunder storm, or when the sky has been clear and serene; whence we infer that these phenomena are unconnected with the state of the atmosphere. The most remarkable characteristics of these stones is, that they resemble each other; yet they are totally different from any known terrestrial substance; and present, in all cases, the same appearance of semi-metallic matter, coated on the outside with a thin black incrustation. It is not, however, in appearance only that their similarity is discovered; they have been submitted to chemical analysis, in all cases yielding the same substances, and in very nearly the same proportions. The stone which fell at L'Aigle in France, in 1803, was found to contain 54 parts of silica; 36 of oxyde of iron; 9 of magnesia; 3 of oxyde of nickel; 2 of sulphur; 1 of lime. And all that have been analyzed have given nearly the same results. The specific gravity of these bodies is also nearly the same, exceeding common stone, and approaching that of metallic ores, being about 3.400, or nearly 3½ times that of common water. These general constant characters indicate a common origin, and hypotheses have been advanced to account for these singular phenomena. Some attribute them to terrestrial, and others to lunar, volcanoes; they have again been supposed to be concretions formed in the regions of our atmosphere; while others have considered them as small planets circulating about the sun or earth, which coming in contact with our atmosphere, take fire from the resistance and friction they experience in passing through it.

With regard to the first supposition, *viz.* that these stones proceed from terrestrial volcanoes, it will be sufficient to observe, that no remarkable eruption has been known to have happened at or near the time of their fall, and that such bodies have been found at the distance of some thousand miles from any known volcano; besides, the immense force that would be necessary to project bodies, some of them of many hundred weight, to so great a distance, far exceeds any force that we can conceive to arise from volcanic eruptions.—As to the theory, that they proceed from volcanoes in the moon, it has a greater degree of probability. The same force that would project a body from the moon to the earth, would not, if it were exerted at the earth's surface, send the same body to the distance of ten miles; in consequence of the superior gravity of our planet, and the density of the atmosphere. It is computed, that a body projected from a favourable spot on the moon's surface, say the centre of her disc opposite the earth, with a velocity about four times that commonly given to a cannon ball, or, 8220 feet per second, would carry it beyond the centre of attraction, and consequently into the sphere of the earth's activity; whence it must necessarily either fall to the surface of the earth, or circulate about us as a satellite. The time a body, so projected, in its passage from the moon to the earth, would take three days; which is not so long but that it might retain its heat, particularly as it is doubtful whether in passing through a vacuum, or very attenuated medium, it would be possible for the caloric to escape, not to say that it might acquire a fresh accumulation of heat, by passing through the denser parts of our atmosphere. Besides, eruptions, resembling those of our volcanoes, have been frequently observed in the moon, and her atmosphere is extremely rare, presenting but little resistance to projected bodies: it will then be seen that this hypothesis, though apparently extravagant, is much more probable than the one we before examined.—With regard to the theory of these bodies being concretions formed in the air, there is one principal objection, *viz.* that the velocity with which they strike the earth, estimated by the depth to which they have been known to penetrate, is so great as to indicate their having fallen from heights far exceeding the limits of the terrestrial atmosphere.—It only remains to notice the supposition of their being little planets, which in the course of their revolutions get entangled in our atmosphere, and by the resistance they experience, have their projectile velocity destroyed, which brings them to the earth. On this hypothesis it is difficult to account for the strong appearance of recent fusion that these bodies possess, which can hardly be attributed to the friction experienced in passing through the medium of our air. Besides, it would exhibit the first mark, which any where appears, of want of order, uniformity, and durability, in the works of the Deity: to have this grand machine thus falling to pieces and to decay, from the mere operation of external causes, but ill accords with that wisdom, power, and omniscience, which are so strongly indicated in all the works of the creation. The difficulties, however, are fairly stated, and the reader of course will draw his own conclusions.

The following is an Abstract *of a* Table, *drawn up by* M. Izarn, *a Philosopher, who has paid great attention to this subject; it exhibits a collection of the best authenticated modern instances of these phenomena.*

SUBSTANCES.	PLACES WHERE THEY FELL.	PERIOD OF THEIR FALL.	TESTIMONY.
Shower of stones	at Rome	Tullius Hostilius	Livy.
Shower of stones	at Rome	Cons. C. Mar. and M. Torq.	J. Obsequens.
Shower of iron	in Lucania	Age of Crassus	Pliny.
Shower of mercury	in Italy	unknown	Dion.
A very large stone	near the river Negos, Thrace	second year 78 Olympiad	Pliny.
Three large stones	in Thrace	before Christ 452	Ch. of Count Marcellin.
Large stone of 260lb.	Ensisheim, Upper Rhine	November 7, 1492	Butenschoen.
Mass of iron, 14 quint	Abakank, Siberia	very old	Pallas, Chladni, &c.
About 1200 stones; one of 120lb, another of 60lb.	Padua, in Italy	in 1510	Cardan, Vascit.
Stone of 59lb	On Mount Vaiser Province	November 27, 1627	Gassendi.
Two large stones	Ireland	in 1695	Musschenbroeck.
Stone of 72lb.	Macedonia	January, 1706	Paul Lucas.
Shower of sand for 15 hours	in the Atlantic	April 6, 1709	Père la Feuillée.
Shower of stones	Barboutan, near Roquefort	July, 1738	Darcet, jun. Lomet, &c.
Shower of stones	at Plann, Bohemia	July 3, 1753	B. de Born.
A stony mass	Niort, in Normandy	in 1750	De Lalande.
Two stones of 200 and 300lb	near Verona	in 1762	Acad. de Bourd.
A stone of 7½lb.	at Luce, in Le Maine	September 13, 1768	Bachelay.
A stone	at Aix, in Artois	in 1768	Gurson de Boyaval.
A stone	in La Contentin	in 1768	Morand.
Great shower of stones	Environs of Agen	July 24, 1790	St. Amand, Baudin, &c.
Twelve stones	Sienna, Tuscany	July, 1794	Earl of Bristol.
A stone of 56lb	Wold Cottage, Yorks.	December 13, 1795	Captain Topham.
A stone of 10lb	in Portugal	February 19, 1796	Southey.
A stone of 20lb	Salé, Department of the Rhone	March 17, 1798	De Drée.
Shower of stones	Benares, East Indies	December 19, 1798	Lloyd Williams, Esq.
A stone of 20lb	Sales, near Villa Franche	March 12, 1798	Ze Drée.
Mass of iron, 70 *cub. ft.*	America	April 5, 1800	Philosophical Magazine.
Several stones, from 10 to 17lb	near l'Aigle, Normandy	April 26, 1803	Fourcroy.

AEROGRAPHY, a description of the air, or atmosphere, as to its limits, dimensions, properties, &c.

AEROMETRY, the science of measuring the air, its powers, and properties; including the laws of motion, gravitation, pressure, elasticity, refraction, condensation, &c. of the atmospheric fluid. *See* Pneumatics.

AERONAUT, a person who floats aloft in the air in a balloon.

AEROSTATION, the art of navigating the air, both in its principles and practice, in *aerostatic machines*, or *air* balloons.—No discovery was ever made, which drew after it more general admiration, or excited more extravagant hopes, than the art of aerostation; yet, after the lapse of 40 years, slender indeed have been the additions made to science by its discoveries, while humanity has had to mourn over the loss of several individuals of spirit and enterprise.

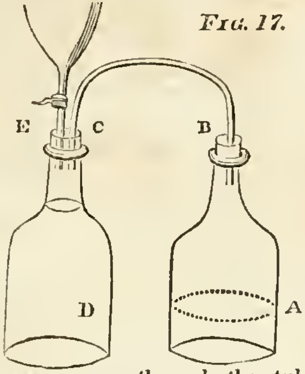
The Principles of Aerostation are simply these:—1. Any body which is specifically lighter than the air, bulk for bulk, will be buoyed up by it, and ascend, till it enters a stratum of the atmosphere in which the weights are equal, and then it will remain stationary, or float horizontally, or descend. An air balloon, then, is a machine, the whole mass of which is of less specific gravity than the air in which it rises. 2. Heat rarefies, expands, and lessens the specific gravity of air, till its weight is proportional to the heat; and 435 degrees of heat will just double the bulk of a volume of air. If, therefore, the air enclosed in any kind of covering be heated, and consequently dilated, to such a degree as that the excess of the weight of an equal bulk of common air above the weight of the heated air, is greater than the weight of the covering and its appendages, this whole mass will ascend in the atmosphere; till, by the cooling and condensation of the included air, or the diminished density of the surrounding fluid, it becomes of the same specific gravity with the air in which it floats, and without renewed heat it will then gradually descend. If, instead of heating common air, enclosed in any covering, and thus diminishing its gravity, the covering be filled with an elastic fluid lighter than atmospheric air, so that the excess of the weight of an equal bulk of the latter, above that of the enclosed elastic fluid, be greater than the whole burden of the machine with its accompaniments, the whole mass will mount into the air, as in the former case, and continue to rise in it till it attains an altitude at which the surrounding air is of the same specific gravity with itself.

Inflammable Air, for balloons, is obtained by applying acids to metals; or subjecting animal, vegetable, and mineral substances in a close vessel, to a strong heat; or by transmitting the vapour of certain fluids through red-hot tubes; or, finally, from carburetted hydrogen gas, which is nothing more than the smoke of coal purified. In the first of these methods, iron, zinc, and vitriolic acid, are the materials most commonly used: the vitriolic acid must be diluted with about five or six parts of water. Iron may be expected to yield, in the common way, about 1700 times its own bulk in gas: or 4½ ounces of iron, the like weight of oil of vitriol, and 22½ ounces of water, will produce one cubic foot of inflammable air: six ounces of zinc, and an equal weight of oil of vitriol, and 30 ounces of water, are necessary for producing the same quantity. It is more proper to use the turnings or chippings of great pieces of iron, than the filings of that metal; because the heat attending the effervescence will be diminished, and the diluted acid will pass more readily through the interstices of the turnings when they are heaped together, than through the filings, which stick closer to one another. The weight of the inflammable gas thus obtained in the common way, by means of acid of vitriol, is generally about one-seventh of the weight of common air; but with the necessary precautions for philosophical experiments, it will be less than one-tenth of the weight of the same fluid. The other elastic fluids that are generated with the inflammable air, may be separated from it by passing the inflammable air through water in which quicklime has been dissolved; the water will absorb these fluids, cool the inflammable air, and prevent its over-heating the balloon when it is introduced into it. But, at a much cheaper rate, gas for balloons may be had from pit-coal, asphaltum, amber rock oil, oak, and other minerals. A pound of pit-coal exposed to a red heat, yields 3 cubic feet of gas; or, according to Glegg's improvements, one chaldron of Wallsend coals will yield 25,000 cubic feet of gas; and the specific gravity of this gas is 0·555, atmospheric air being 1·; though, in some books, you are told pit coal gas weighs only ½ of common air.

To Make the Gas for Balloons.—Small balloons may be filled with gas, after passing it through water. See the annexed apparatus, fig. 17. A is a bottle that contains the ingredients mentioned above. B, C, is a tube which conveys the gas through the water in the bottle D. In the cork at E, another tube allows the gas to pass into the balloon; or two small casks may be used in place of bottles.—Another method for producing the hydrogen gas is represented in fig. 18. ABC is a vessel of clay or iron, into which the materials yielding the gas are introduced, so as to occupy 4-5ths of its cavity. This vessel is subjected to the action of fire, if it contain coal; the gas passes through the tube CD, and also through the water in the tub H, into the inverted vessel EF, to the upper aperture of which the balloon G is tied to receive the gas. The fire should be at a considerable distance from the tub H, that the inflammable air, if any escape, may not explode and do mischief.

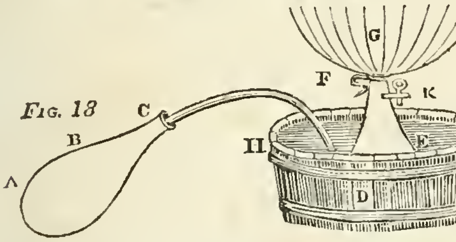
Hydrogen Gas.

FIG. 17.



Balloon Gas Apparatus.

FIG. 18



The old apparatus for filling an inflammable air balloon of the largest dimensions, is represented in fig. 19. A, A are two tubs, or gasometers, about three feet in diameter and nearly two feet deep, inverted in larger tubs: at the bottom of each of the inverted tubs there is a hole, to which is adapted a tin tube, E, about seven inches in diameter, and seven or eight inches long. To these tubes the silken tubes of the balloon are tied. Each of the tubs, B, is surrounded by several strong casks, so regulated in number and capacity, as to be less than half full when the materials are equally distributed. In the top of each of these casks are two holes; and to one of the holes is adapted a tin tube, formed so as to pass over the edge of the tub B, and through the water, and to terminate with its aperture under the inverted tub A. The other hole, which serves for supplying the cask with materials, is stopped with a wooden plug. These tin tubes may be about three inches and a half diameter, and the other holes may be smaller. Two masts, with a rope, &c. are used for this machine, although they are not absolutely necessary; because the balloon, by means of a narrow scaffold, or other contrivance, may be elevated five or six feet above the level of the tubs A, A. When the balloon is to be filled, the net is put over it, and suspended as exhibited in CDF: and having expelled all the common air from it, its silk tubes are fastened round the tin tubes EE, and the materials in the casks are properly proportioned, the iron being first put in, then the water, and lastly the vitriolic acid. The balloon will soon be inflated by the inflammable air, and support itself without the aid of the rope GH. As the filling advances, the net is adjusted round it; the cords proceeding from the net are fastened to the hoop MN; the boat, IK, is suspended from the hoop MN, and every thing necessary for the voyage is deposited in it. When the balloon is a little more than three-quarters full, the silken tubes are separated from the tin tubes, and their extremities being tied, they are placed in the boat. Finally, when the aeronauts are seated in the boat, the lateral ropes are slipped off, and the machine ascends in the air, as in fig. 20. In order to produce such a bulk of inflammable air as is necessary for a balloon of 30 feet in diameter, whose capacity is 14,137 cubic feet, there will be required about 3900 lbs of iron turnings, 3900 lbs of vitriolic acid, and 19,500 lbs of water, with which the balloon will not be above three-quarters full. The usual way now of filling a balloon with the carbonated, or carburetted, hydrogen gas, the same as the streets are lighted with, is to introduce it through any service pipe into the balloon, from any of the station pipes connected with the gasometer of any of the great gas manufactories in the neighbourhood of the aeronaut's ascent. Of course, all the apparatus of casks, &c. is done away with: but some degree of caution is requisite in managing the machine when afloat, and highly elevated; for should the larger valve in the top of the balloon be opened by the aeronaut in place of the smaller one, as unfortunately was done by the late Mr. Harris, too much gas may escape, and the vehicle be precipitated with

Fig. 19.

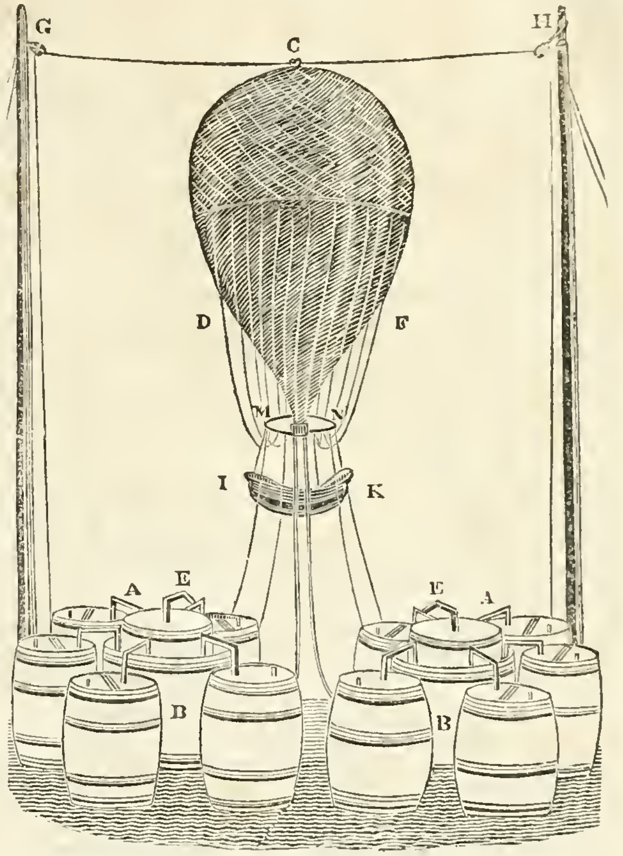
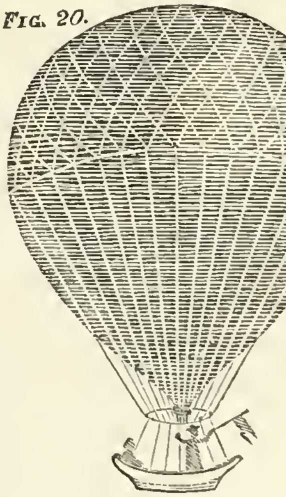


FIG. 20.



great velocity perpendicularly to the ground. Mr. Harris ascended from the City-Road, London, May 25, 1824, and in the neighbourhood of Croydon, Surrey, his balloon came rapidly to the ground, from his having pulled the cord of the larger in place of that of the smaller valve, to descend; and he was killed on the spot. His fair companion, a young lady, was very much injured by the fall.

Construction of Balloons.—The balloon itself is composed of gores of silk, fig. 21, covered with caoutchouc varnish, and probably 30 feet diameter. A net is spread over the whole hemispherical surface. To this a car or boat is suspended by ropes, so as to hang a few feet below the balloon; and in order to prevent the bursting of the machine, a valve is placed in it; sometimes two valves, one within the other, to allow the gas to escape when the aeronaut wishes to descend. The basket may be 8 feet long, 4 wide, and 3½ deep, of wickerwork; and the weight of the whole apparatus about 5½ cwt. including the voyager.—The conduct of balloons has been attempted to be placed under the power of the aeronaut, by means of wings or oars, fig. 22. Blanchard used this sort of wing of silk, stretched upon cane, and used edgewise in the direction in which the balloon is driven.—Lunardi tried shutters of silk, or rather valves, *a*, *b*, *c*, as fig. 23, to open on one side only, and be moved on the flat side in the direction in which the machine is impelled. But the aeronaut has little or no power over the machine when it is suspended in the air.—Baldwin, who ascended from Chester in 1785, compares the sensation of ascending to that of a strong pressure from the bottom of the car upwards against the soles of the feet. At the distance of one mile he fancied he had gone seven. The river Dee appeared red, the city diminutive, the town blue, and all reduced to one grand enchanting level; the clouds seemed a sea of fleecy cotton, the thunder-clouds like the dense smoke of cannon. The shadow of the balloon upon the white floor of clouds, was, at times, no bigger than an egg; at others, greatly increased, and surrounded with the most captivating iris or rainbow. At four miles high the air was warmer than on earth: the sun was hottest when the balloon was stationary.—Mr. Sadler, who, in the summer of 1824, ascended from Liverpool, erected an extensive apparatus for filling his balloon with gas, of a quality sufficiently buoyant to bear up more than the usual weight. The apparatus consisted of a large boiler, heated by two furnaces, and a number of cylindrical retorts, communicating by pipes, leading to a general conduit;—the whole being on the principle of simply decomposing water by means of heated iron filings, borings, and turnings. The balloon was 34 feet diameter, by 42 feet high, covered with 560 square yards of silk, containing 28,000 cubic feet of gas, which would raise 12 cwt. from the earth. The balloon arose at 3 p. m. and took a S.E. course towards Chester, near which place it descended between 5 and 6 p. m. The mountains of Wales were visible to Mr. Sadler and his companion; but the sea was hid by clouds.—On the 14th of June, 1824, Messrs. Green and Sparrow ascended from the gas-works of Oxford, about 3 p. m. The balloon travelled 22 miles towards Henley, where it was brought down. Mr. Sparrow was thrown out of the car, when the balloon came first in contact with the earth, but received no injury.—A Mr. Graham and his wife, about the same period, ascended from London, and descended about 14 miles from Brighton, after a voyage of 1 hour and 20 minutes, without experiencing any accident.—Since the above was written, poor Sadler was killed in one of his enterprising voyages.

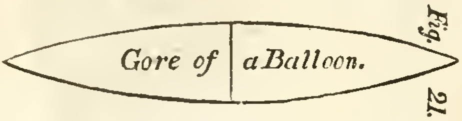


Fig. 21.

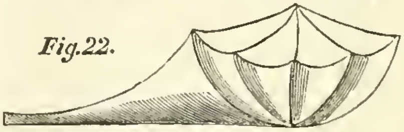


Fig. 22.

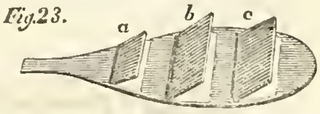


Fig. 23.

ÆSCULUS, in Botany, horse-chesnut, which, as a powder, excites sneezing: infused, it is good for complaints in the head and eyes. The bark of the tree is considered a good febrifuge.

ÆSTIVAL, belonging to summer, as the æstival solstice, sign, &c.

ÆTHER, in Chemistry, a light, volatile, and very inflammable liquid, produced by distillation of acids with spirits of wine. The too frequent use of æther is very injurious to the nervous system; yet many people take it freely.

ÆTHUSA, fool's parsley, possesses poisonous qualities.

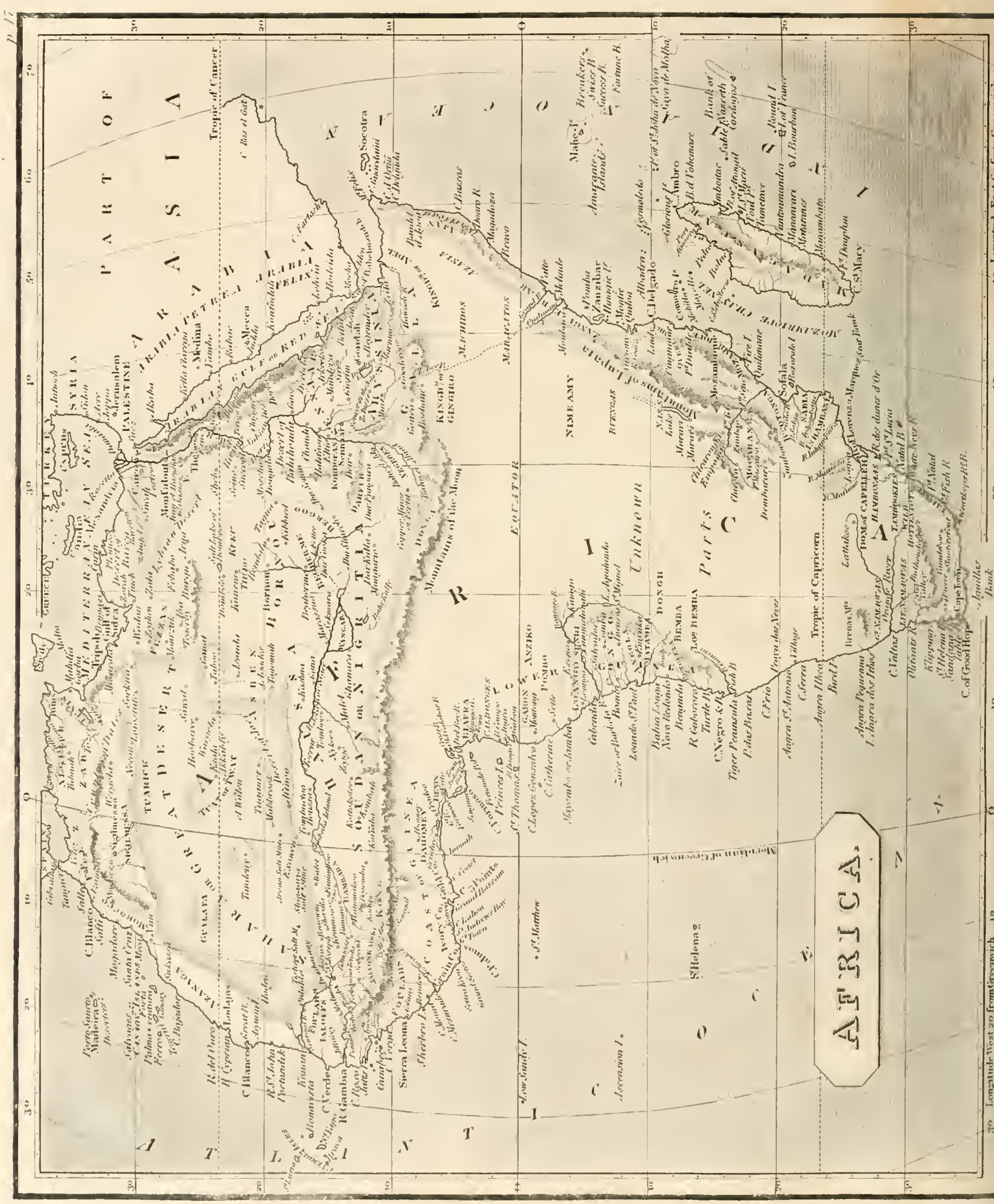
AETITES, eagle stones, flinty crustated pebbles, of a yellow colour, hollow within, and containing a nucleus, which rattles if the stone be shaken.

AFFERERS, in Law, persons appointed in courts leet, courts baron, &c. to settle the fines upon those who have been guilty of faults arbitrarily punishable.

AFFETTUOSO, or *Con Affetto*, in Music, whatever is played in a moving style.

AFFIDAVIT, in Law, an oath in writing, sworn before a competent authority.

AFFINITY, in Chemistry, is that power which tends continually to bring particles of substances together which are disunited, and which retains in connection, with more or less force, those already in a state of combination. When olive oil and water are shaken together, they refuse to act upon each other, and separate according to the order of their densities, the oil swimming above the water. Oil and water will not mix intimately; they will not *combine;* and are said to have no chemical *attraction* or *affinity* for each other. But if oil and soap lees, or solution of potash in water, be mixed, the oil and the solution blend together, and a species of soap will be formed, which may be procured as a soft solid substance by evaporating a part of the water. This is an instance of *combination;* and solution of potash and oil are said to *attract* each other chemically, or to have an *affinity* for each other. A spoonful of salt, thrown into a vessel of water, diffuses itself through the whole of the fluid, and the salt is combined with the water; the water and the salt have an affinity for each other, and cannot be separated by any mechanical means: but if another substance be introduced, to which water has a greater affinity than it has to the salt, it will quit the salt, to unite to this third substance. If alcohol be the third body, the water will leave the salt to join the spirit; and the salt, by its superior gravity, will be precipitated in the vessel. Alcohol will dissolve camphor, and the fluid be perfectly clear, which is another instance of chemical combination; the two substances have a strong affinity for each other: but the spirit has a still stronger affinity for water than for the camphor; and if a little of that fluid be added to the solution, the camphor will fall down in flakes, that is, in a solid form. Different bodies unite with different degrees of force; and hence, one body is capable of separating others, from certain combinations: and in consequence of the same circumstance, mutual decompositions of different compounds take place. This has been called *double affinity*, or *complex chemical attraction*. Thus, if an aqueous neutral solution of lime and nitric acid, and a like solution of magnesia and sulphuric acid, be mixed together, the lime will quit the nitric acid, to unite to the sulphuric acid, and the magnesia will leave the sulphuric acid, to combine with the nitric acid. The combination of nitric acid and magnesia will remain in solution; but the compound of lime and sulphuric acid, being only slightly soluble in water, will, for the most part, be precipitated in the form of a white powder. Every substance has its peculiar affinities to the various other substances presented to it. If all bodies had the same degree of affinity with each other, no change could take place amongst them; and we should not be able to displace any principle by presenting one body to another. It is in consequence of this difference in the affinities, that all chemical decompositions are affected; and all the operations of nature and art are founded upon it. Hence arises the terms, *simple* affinity, *double* affinity, &c. Two principles united, and then separated by means of a third, afford an example of simple affinity: it consists in displacing one principle by the addition of a third. The body disengaged is called the *precipitate;* the substance used to separate the compound, is called the *precipitant*. An alkali precipitates metals from their solutions. Sometimes the low



AFRICA

Longitude West 20 from Greenwich
Longitude East 60 from Greenwich
PART OF ASIA
ARABIA
ATLANTIC OCEAN
INDIAN OCEAN
MEDITERRANEAN SEA
Tropic of Cancer
Tropic of Capricorn
EQUATOR
Meridian of Greenwich
Unknown Parts
SAHARA or GREAT DESERT
NIGRITIA
GUINEA
LOWER GUINEA
ABYSSINIA
NUBIA
EGYPT
Mountains of the Moon
MADAGASCAR
C. of Good Hope
St. Helena
Ascension I.

compound itself is precipitated, as when the vitriolic acid is poured on a solution of the muriate of lime. At other times, the disengaged body, and the new compound, are precipitated together, as when Epsom salt is dissolved in water, and precipitated by means of lime water. The compound of two principles cannot be destroyed either by a third or fourth body separately applied: but if these two bodies be united, and then brought into contact with the same compound, a decomposition will take place. This phenomenon constitutes *double affinity*, as when *vitriolated tartar* is decomposed by nitric acid combined with lime.

AFFIRMATION, in Law, an indulgence allowed to the people denominated Quakers; giving them the privilege of deposing upon their mere word of honour, what other sects must attest upon oath. If the Quaker in this perjures himself, he suffers accordingly.

AFFRONTEE, in Heraldry, an appellation given to animals fronting one another in an escutcheon.

AFRICA, [*Map*,] one of the four great divisions of the earth, extending from north to south about 70°, or 4200 geographical miles. This vast continent occupies about 69° of longitude, or 4140 geographical miles. It is divided into Abyssinia, Egypt, the Mahometan States in the North, the Western Coast, the Cape of Good Hope, and the countries on the Eastern shores. The islands are, Madagascar, Bourbon, Mauritius, Kerguelen's Land, St. Helena, the islands of Cape Verd, the Canaries, and Madeira. The ruling religion is Mahommetanism. The climate in the north is hot, in the south temperate. We know of no navigable rivers and lakes that can diffuse commerce from the shores to the centre of Africa. The chief rivers are the Nile, the Niger, the Senegal, the Zahir of Congo, and the Zambezi of Mocaranga. The mountains are those of Atlas, Abyssinia, and the Cape. And the great desert of Zaara stretches from the shores of Africa to the confines of Egypt, in length 2500 geographical miles, by a breadth of 720; and though interspersed with fertile spots, it is a vast ocean of sand, that defies every exertion of human industry.—[N.B. The geographical portion of this Dictionary is from one of the Editor's own works—the GRAMMAR OF GEOGRAPHY.]

Abyssinia, is bounded on the north and west by the mountains and forests of Kordofan and Sennaar; on the south, deserts and mountains separate it from Gingiro and Alaba, and the Red Sea skirts its eastern margin. It is divided into the provinces of Tigri, Gojam, Dembea, and Gondar, the capital. The religion is the Christian; the population may amount to three millions; and the government is absolute and hereditary monarchy. The climate is greatly diversified; for from April to September there are heavy rains, and though the six following months be dry, the nights are cold. No country can match Abyssinia in mountains and detached precipitous rocks. The African Alps are crowned with eternal snow, and from those of Kumri, issue the unexplored sources of the Nile. The chief lake is that of Tzana, called also Dembea, and lakes Zawaja and Haik. The horses of Abyssinia are small, but spirited; cattle and buffaloes are numerous; the elephant, the rhinoceros, the lion, the panther, the camelopardalis, are met with; hyænas infest Gondar at night; wild boars, gazelles or antelopes, and monkeys, swarm in the woods; the lakes and rivers abound in hippopotami and crocodiles.

Egypt, celebrated from all antiquity, is about 500 miles long, and nearly 250 broad. The entire country is a narrow vale, bisected by the Nile, and hemmed in by parallel ridges of mountains. The prevailing religion is Mahommetanism, but there are many Christians, who have their priests and monasteries. The population is about two millions and a half. The government is in the hands of a viceroy of the Ottoman power; though, in Cairo, a powerful aristocracy directs the affairs of domestic policy. The people are in general filthy; the Copts, or original Christian inhabitants, are the men of business. The climate is peculiar, rain being uncommon, the heat extreme, enforcing an abstemious diet; the soil rich, agriculture of the simplest kind, the inundations of the Nile rendering vegetation luxuriant without much manual labour. The chief city is Grand Cairo, a dirty place, filled with 300,000 souls, pent up in narrow streets; Alexandria, Rosetta, and Damietta. Egypt, once the focus of oriental trade, and the granary of Rome, still exports vast quantities of wheat, rice, and flax, and many black slaves; and from Tunis and Tripoli it receives oil, red caps, and fine flannel; from Syria, cotton, silk, soap, and tobacco; from Constantinople, white slaves, Circassians or Georgians, the males being the far-famed but ill-used Mamelukes. The chief river is the Nile, about one quarter of a mile broad, and twelve feet deep, of muddy water, but abundant in a species of salmon, eels, and crocodiles. The chief lakes are those of Menzala, Berelos, and Elko, in the north; Kerun in the west, and the Natron lakes, producing mineral alkali. The mountains lie chiefly between the Nile and the Red Sea. The pyramids are constructed of free-stone, like that used at Bath; and the ancient obelisks were dug out of quarries of red granite near Syene. The lotus or water lily decorates the Nile; the cypress overshadows the tombs of the dead; the sycamore flourishes with vigour even on the sandy frontiers of the desert; and the papyrus, sacred to literature, is found in the marshes of the Delta.

Nubia, or Ethiopia, 600 miles in length, and 500 in breadth, is an extensive tract between Egypt and Abyssinia. Its states are, Dongola in the north, and Senaar in the south. Nubia is a miserable country, and its people deceitful and ferocious.

The Mahommetan States in the North, are, Tripoli, Tunis, Algiers, and Morocco, extending from Cabes to the confines of Egypt. Tripoli is governed by a Bey, subject to the Porte or Sultan. The town is situate in a low spot, and is in a state of rapid decay. Tunis, the central region of northern Africa, was once the seat of the Carthaginian power. The ruins of Carthage are not far from Tunis the capital, a town about three miles in circumference, and containing 50,000 souls, the most polite and civilized among the Mahometans of Africa. Lions, panthers, hyænas, and other ferocious animals, are found here. Algiers is governed by a Dey or Pasha, who exacts tribute from the maritime states of Christendom; and whose country is a nest of robbers. The kingdom of Algiers comprises the Numidia, and part of the Mauritania, of the ancients; and the productions are wool, lead, oil, leather. There are many salt springs and rivers in the kingdom of Algiers, and there is one salt hill near the lake called Manks. The empire of Morocco, which includes also the kingdom of Fez, is peopled by civilized Moors, and wandering, but hospitable Arabs; but the Brebers, from whom Barbary takes its name, are fierce and obstinate descendants of the aboriginal inhabitants. The universal food consists of bits of paste cooked by the steam of boiled meat and vegetables, sewed up in an earthern dish, with butter and spices, and eaten alike by the peasant and the monarch. The chief sea-port is Tetuan. Morocco is the capital. But on the south of these Mahommetan states, there are the countries of Drab, Sijelmissa, and the Land of Dates.

The Western Coast, is peopled by the Jalofs and Foulahs, on the banks of the Senegal and Gambia. Guinea is divided into the grain, the ivory, and the gold coast. Benin and Calabar, Congo and Angola, come next in order. The sovereign of Benin is said to be able to bring into the field 100,000 warriors. Laonga, on the north of Congo, possesses an industrious population, expert in weaving, smith's work, and the manufacture of canvass, caps, and beads. The Congoese have the negro colour, without the features; and these people practise the strange custom of opening the graves annually, to decorate the bones of the dead. These countries are well watered, and the usual tropical plants abound; rice, yams, gourds, potatoes, and melons, are the chief food of the inhabitants.

The Colony of the Cape of Good Hope. The territory of this colony is about 550 miles in length, and 233 in breadth, comprising a population of about 20,000 souls. The country is more fertile towards the east than on the western coast; and the chief roadsteads are False Bay on the south, and Table Bay on the north, which opens to Cape Town. The botany of southern Africa is peculiarly rich and magnificent, as is proved by the beautiful plants from thence, which decorate our British green-houses. And wolves, hyænas, antelopes, eagles, vultures, kites, crows, turtle doves, lions, and hippopotami, rank in the natural history of the Cape of Good Hope.

The Eastern Coast, includes the country of the Kaffres, or Koussis, and the Tambookies. The coast of Natal is followed by the Bay of Delagoa. Opposite to Madagascar are

Sabia, Sofala, Mocaranga. Then the coasts of Mozambico and Zanguebar; and the desert and obscure coasts of Ajan and Adel, complete the circuit of Africa. The country around the Bay of Delagoa abounds in cattle and poultry, and the fish are numerous and excellent; Deer Island affording abundance of turtle. The natives are Kaffres, that is, Pagans, of a bright black colour, tall and stout, good humoured and harmless. Mocaranga is inhabited by a civilized people, who are nevertheless superstitiously afraid of magical charms. The king is guarded by females. The spade, the emblem of agriculture, is worn by the king on days of ceremony, in place of a sword. An officer is sent annually to each province, and, in token of his fidelity, leaves his children as hostages at court. The people of the province, on the officer's appearance, extinguish their fires, but again light them from the officer's torch, in token of their loyalty. On the coasts of Ajan and Zanguebar there are considerable numbers of Moors: Mozambique is subject to the Portuguese; Zanguebar abounds in elephants. Of the other states little is known. Madagascar, 840 miles long, and 220 broad, abounds in grand and picturesque scenery, strikingly diversified with precipices, cataracts, and immense forests. The chiefs of tribes in this island are distinguished from their clan by *red* caps; the villages are fortified places, constructed on eminences; the magicians have an amazing sway over the more ignorant natives; and the most honourable trade is that of a butcher.—The islands of Pemba, Zanzibar, and Monsia, are opposite to the coast of Madagascar; and the isles of Mahé, and Almiranti, are considerably to the east. The isles of Comoro are Angazzia, Anzoan, &c. governed by Mahometan chiefs, tributary to the Portuguese; and the domestic animals are, in general, like the European. The islands of Mauritius, or France and Bourbon, now in the possession of Great Britain, are to the east of Madagascar. These islands produce yearly two crops of wheat and Indian corn, and Bourbon is celebrated for its sugar canes, cattle, breadfruit, nutmeg and cinnamon trees. Kerguelen's Land, or the *Island of Desolation*, situate in the centre of the great Southern Ocean, is noted chiefly as the resort of ships on the seal fishery; for its wildness and sterility set industry at nought. St. Helena has only one harbour, and that is difficult of access. This island is the regular resort of the East India Company's ships, and was lately remarkable as the residence of Buonaparte. The island of Ascension has an excellent harbour, and abounds in turtle and sea-fowl; but the country is mountainous, and the soil barren. The isles of St. Matthew, Annabon, St. Thomas, Prince's Isle, and Fernando-Po, are near the African shore.

The Interior Parts of Africa.—Darfur, a kingdom in the interior of Africa, has a capital called Cobbe, and the inhabitants are almost all merchants and foreigners. The flocks of sheep and of goats here are numerous; cows and camels abound; lions, leopards, hyænas, wolves, jackals, wild buffaloes, elephants, rhinoceroses, antelopes, and ostriches, are plentiful. Copper and iron are met with in vast mines; tamarinds and fruit-trees are common. The government is hereditary monarchy; but the Darfurs are a dissolute, wanton people, amounting to about two millions of souls. The Moorish kingdom of Ludamar, that of Beeroo, Tombuctoo, Kaarta, and Bambarra, have been described by that enterprising and ingenious traveller, Mungo Park. Also the kingdoms of Houssa, Kassina, Gotto, Baëdoo, and Maniana; Kulla, Bergoo, Fur, Bornou, and Ashantee, by other travellers.

AGALLOCHUM, a fragrant medicinal wood, brought from the East Indies.

AGAPE, a love-feast, or feast of charity, as practised by the first Christians, who had all things common. This feast has been revived by the Wesleyan Methodists, and by some sects of Particular Anabaptists.

AGARIC Earth, found in fissures of rocks, roofs of caverns, &c. and sometimes used as an astringent in fluxes, hæmorrhages, &c.

AGARICUS, the botanical name of the mushroom.

AGATE, a precious stone, either yellow or green, lead-coloured, or sanguine. Agates may be obtained artificially with solution of silver in spirit of nitre, and afterwards exposing the part to the sun. The most remarkable agate was that of Pyrrhus, in which was depicted the nine muses, and Apollo playing on a harp. There is one on the continent, in Austria, we believe, fashioned into a cup nearly an ell in diameter.

AGAVE, the American aloe.

AGE, in ancient Chronology, the space of 30 years; thus, Nestor lived 3 ages, or 90 years; but sometimes it denotes 100 years. In Law, a certain period of life, as 21 years, when a person is said to be *come of age*.

AGER, a Roman acre of land.

AGERATUM, bastard hemp agrimony.

AGGER, in ancient warfare, a fortified work to defend a camp or position; in modern tactics, the lines of approach, or trenches, correspond with the *aggere* of the ancients.

AGGREGATE, the sum of several things added; and *Aggregation* is the mass, as a heap of sand, of ruins, &c.

AGIO, in Commerce, the difference between bank stock and current coin, in Holland and Venice.

AGMEN, a Roman army in march, which consisted of three *agmina*, or divisions; van, main body, and rear.

AGNUS Castus, a plant, upon which the Athenian ladies, who made a profession of chastity, used to lie during the feasts of Ceres.

AGRICULTURAL Instruments, are the plough, harrow, roller, &c. &c.

1. The Plough, fig. 24, is a machine drawn by horses, and guided by a husbandman, for turning up the soil, and preparing it to receive the corn, &c. The chief parts of this instrument are, the *coulter*, W E F; the *sock*, C, fixed on the base C M: M is the *heel*. The sock and coulter are of iron. A L is the *sheoth;* P Q the *stilt;* R L K the *beam;* H the coulter stay. There are ploughs of a different construction to this; but the most remarkable are, the

The Plough.

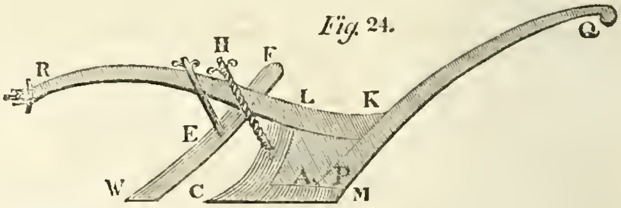


Fig. 24.

2. *Four-coultered Plough*, fig. 25, moving on two wheels, of which the left-hand one is 20, and the right-hand one 24 inches diameter; separated 2 feet 6 inches from each other. The plough beam is 10 feet long.

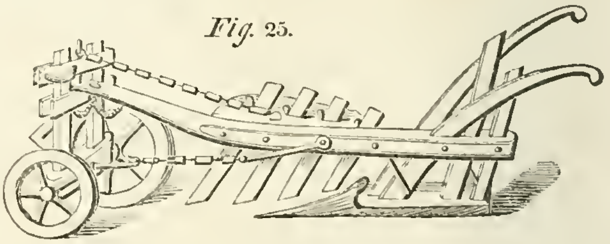


Fig. 25.

3. *The Paring Plough*, represented in fig. 26, will be readily understood from the figure: its use is to pare off the rough stubble, or surface of the ground, in order to its being burnt. E is the paring plate; the beam is seven feet long.

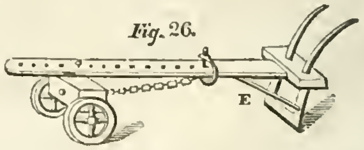


Fig. 26.

5. *The Chain Plough*, fig. 27, so termed because drawn by a chain, fixed to the back part of the beam immediately before the coulter, has two advantages; first, by means of a muzzle, it makes the plough go deep or shallow; and, next, it stresses the beam less than if fixed to the point, and therefore a slenderer beam is sufficient. This plough, of a smaller size than ordinary, can be drawn by a single horse, and is the

most proper for horse-hoeing, making dung-furrows, drills, &c. &c.

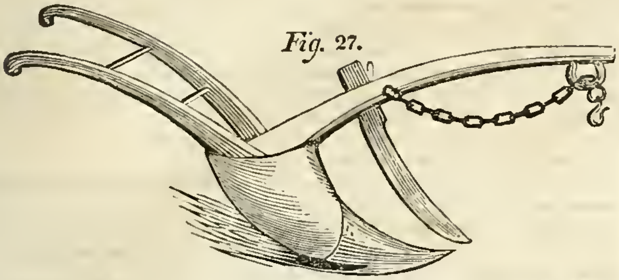
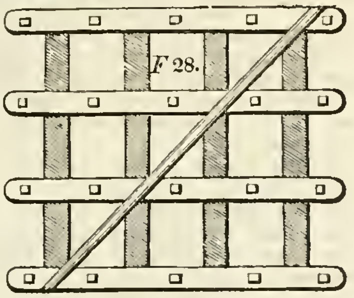


Fig. 27.

5. *The Brake*, fig. 28, a large weighty harrow, is used to reduce stubborn soils. It consists of four pieces of oak, $6\frac{1}{2}$ feet long, 5 inches square; with teeth 17 inches long, bending forward like a coulter.

6. *The Common Harrow* is, in figure, like the brake, but much lighter made: the teeth may be wood or iron, from ten to twelve inches asunder.



F 28.

7. *The Chain and Screw Harrow*, fig. 29, designed to bend with the ridges, either from their crowns, or from their furrows, even if the sides of the ridges be 18 feet broad. This harrow may be differently made; as by joining two common harrows by a chain, so that they shall bend to the curvature of the ridges. In the same way, a grass harrow may be framed when the land is not laid down in meadow form, perfectly level.

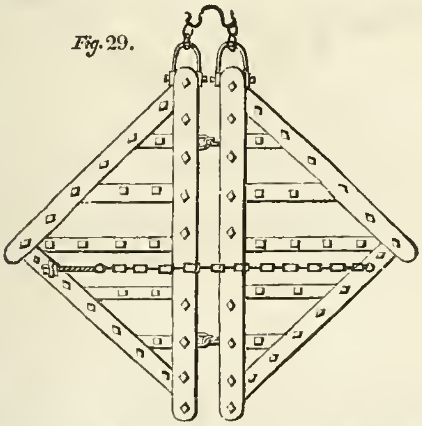


Fig. 29.

8. *The Roller*, made of stone, wood, or cast iron, should weigh 200 stone, without shafts; but constructed of cast iron, it is sometimes a ton and a half weight. A piece of beech wood, surrounded with three rows of felloes, lined with planks equally long, and the whole clasped together with iron rings $3\frac{1}{2}$ feet diameter, makes a good agricultural roller.

9. *The Patent Universal Sowing Machine*, may be made to be worked by hand, drawn by a horse, or fixed to a plough. Simple in its construction, and therefore not readily put out of order, having but one movement to direct the whole, it requires no skill in working; and will sow wheat, barley, oats, rye, clover, turnip seed, &c. with an accuracy hitherto unknown. Fig. 30 represents the machine fixed to a double-furrow creasing plough, and prepared for drilling.

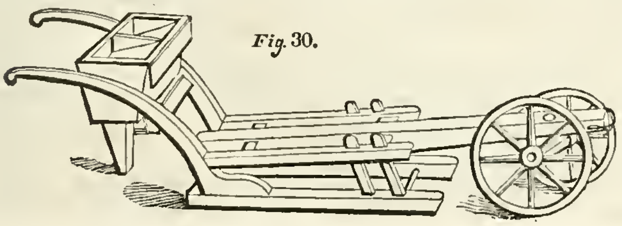


Fig. 30.

10. *The Scythe*, fig. 31, is a well known instrument in husbandry; and the *Silesian Scythe*, which we will here describe, differs little from that commonly used in mowing grass, except that the blade is rather smaller; to it, four teeth of wood are attached parallel to the blade, fixed and secured in a proper manner, and designed to keep the corn together after it is cut; so that, instead of its falling in a confused state, the reaper can lay it down in a regular and compact manner. The handle, *a b*, is 4 feet 3 inches long; the blade, *b c*, about 2 feet; the upright, *b d*, 1 foot 10 inches.

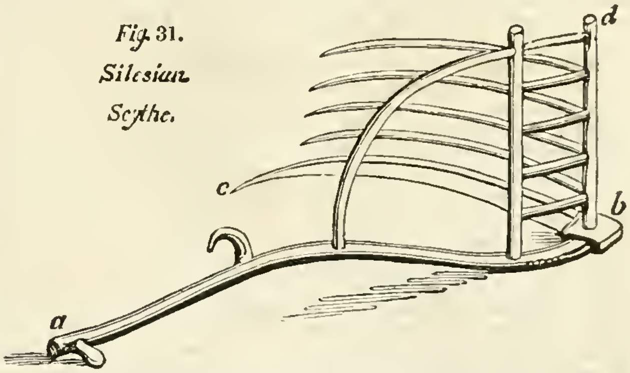


Fig. 31. *Silesian Scythe.*

11. In the *Collector Scythe*, fig. 32, the handle, *a*, is 4 feet 1 inch; the blade, *b*, 2 feet 8 inches; the upright, 12 inches: the collector is of cloth, and may be added to the common scythe with a piece of sheet iron at the tip of the blade. The collector is fixed on by stout iron wires, *c*, and will be well enough understood from our engraving. This instrument is preferable to the above, though both are excellent.

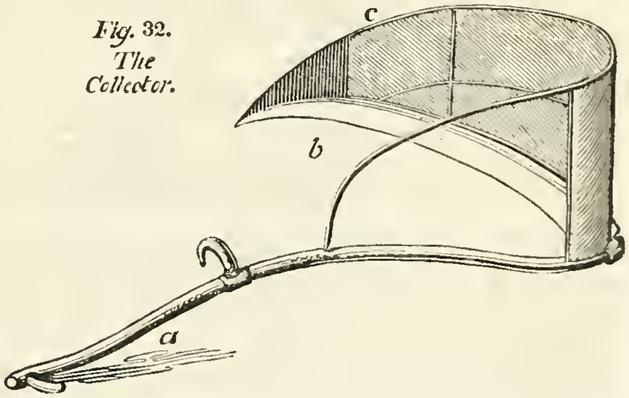


Fig. 32. *The Collector.*

12. *The Irrigating Machine*, is an instrument designed to raise water to a great height for the irrigation of land, in such situations as have the advantage of a small fall: it depends on the principle of Hero's fountain, and it may properly be inserted here. See Hero's fountain, article JET D'EAU. Fig. 33, *a*, *b*, is the stream of water: *b*, *c*, *c*, represents the waterfall, supposed to be 10 feet: *d*, *e*, are two leaden or cast iron vessels, containing about 4 or 6 gallons of water, and *f*, *g*, *h*, *i*, *k*, *l*, are leaden or iron vessels holding about two quarts each: *o*, *p*, are two cocks, each of which passes through two pipes, opening the one, and closing the other: *q*, *r*, is a *water balance*, which works on its centre *s*, and by which the cocks *o* and *p* are alternately turned: *t*, *u*, and *w*, *x*, are air-pipes made of lead, both $1\frac{1}{4}$ inch diameter internally; and *y*, *z*; *y*, *z*; *y*, *z*; are water-pipes, each 1 inch diameter. The pipe *b*, *e*, *c*, is always full from the stream *a*, *b*; the small cisterns, *g*, *i*, *l*, and the large one, *d*, are supposed to have been previously filled with water. The fluid may then be admitted by turning the cock *o*, through

the pipe *c, e,* into the larger cistern *e.* The water will then press the air confined in the cistern *e,* up the air-pipe *w, x,* and force the fluid out of the cisterns *g, i, l,* into those marked *h, k,* &c. At the same time, by opening B, the water and condensed air, which previously existed in the large cistern *d,* and in the less ones *f, h, k,* will be discharged at B. In a short time, the *water balance, q, r, s,* will turn the cocks *o, p,* and push out the water, opening, during this operation, the opposite ones; the cisterns *f, h, k,* are emptied in their turns by the condensed air from the cistern *d,* as the water progressively enters the latter pipe *b, c.*——These, and many more, which our limits compel us to omit, are the most useful machines used in agriculture: Carts, waggons, threshing mills, &c. we shall describe in their proper places, agreeably to the alphabetical arrangement of this Dictionary.

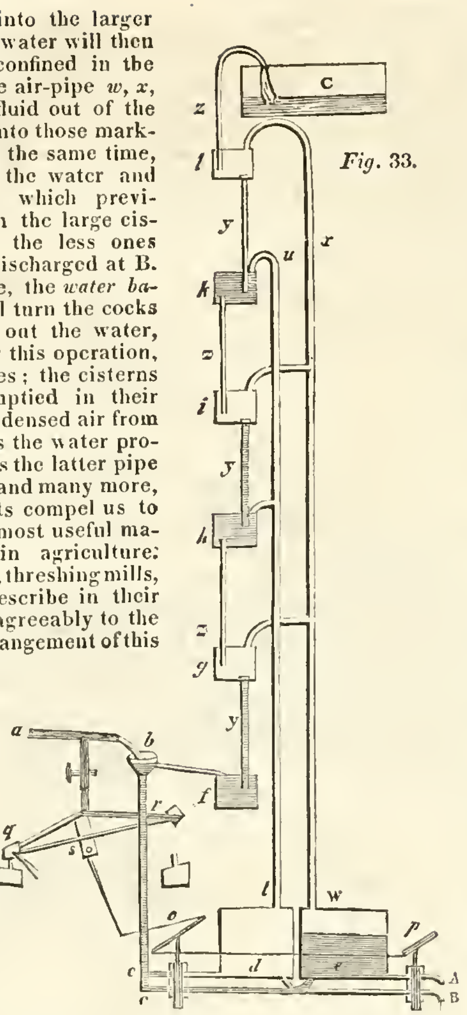


Fig. 33.

AGRIMONIA, Agrimony: *hemp* and *water-hemp* agrimony, occur in botany. Common agrimony is aperient and detergent; good in scorbutic disorders, and debility of the intestines. Digested in whey, it makes a good and useful diet-drink for the spring.

AGROSTEMMA, wild lichens, or campions.

AGROSTIS, bent-grass. *Agrostographia,* the history or description of grasses.

AGUE, a periodical fever, which, according to the different returns of the feverish paroxysms, is denominated tertian, quartan, and quotidian.

AHEAD, a sea term, expresses the situation of any object in advance of the ship; and is used in opposition to *astern,* which denotes the position of any object behind the ship.

AHULL, the situation of a ship when all her sails are furled, on account of the violence of the wind, and when, having lashed her helm on the lee side, she lies nearly with her side to the wind and sea, her head being somewhat inclined in the direction of the wind.

AIDS, in the Manege, cherishings used to avoid the necessary corrections. The *inner aids* are the inner heel, leg, rein, &c; the *outer aids,* the outer heel, leg, rein, &c.

AIGHENDALE, in Lancashire, a liquid measure of 7 quarts.

AIGUISCE, in Heraldry, a cross with its four ends sharpened into obtuse angles.

AIR, a thin, elastic, transparent fluid; ponderous, compressible, and dilatable.

Air, in Music, melody in general, a tune.

Air-*Pipes,* an invention due to Mr. Sutton, a brewer, of London; being intended for clearing the holds of ships, and other close places, of their foul air. The principle upon which this contrivance is founded, is well known; being no other than the rarefying power of heat, which by causing a diminution in the density of the air in one place, allows that which is in contact with it to rush in, and to be succeeded by a constant supply from remoter parts, till the air becomes every where equally elastic. If, therefore, one end of a long tube be placed in the hold, or place to be purified, while the other end of the tube be sufficiently heated, the foul air will be constantly drawn up, and supplied by fresh air from above.

Air-*Pump,* a popular pneumatic machine, that draws out or exhausts the air in a proper vessel. The construction of this machine, and its principle of action, may be thus explained, fig. 34:—Let B represent a section, (the section of a perfectly uniform metallic barrel or pipe,) communicating with the glass receiver A, by means of the inferior tube *t, t*; let P be a piston, attached to the rod R, and fitting the barrel air-tight; *v* and *v,* are two valves opening upwards, one in the piston, the other in the end of the tube *t t.* C D supports the receiver, which is placed on wet leather collars. When the piston-rod is pushed down, the air in the barrel is compressed, the lower valve shut, but the valve of the piston opens, and allows the air in the barrel to rush out. When the piston is drawn up, its valve is shut by the external atmosphere; but the air in the receiver pushing up the valve *v* of the tube, rushes into the barrel, which is again filled with air as much rarer than before, as the contents of both barrel and receiver exceed that of the receiver alone. Every stroke diminishes the density of the confined air in a constant proportion, namely, as much as the whole content exceeds that of the cylinder or barrel; and consequently, the sum of as many diminutions as there are strokes of the piston, will shew the whole diminution by all the strokes. So, if the capacity of the barrel be equal to that of the receiver, in which the communication-pipe is always to be included, then, the barrel being half the sum of the whole content, half the air will be drawn out at one stroke; and consequently, the remaining half, being dilated through the whole or first capacity, will be of only half the density of the first; in like manner, after the second stroke, the density of the remaining contents will be only half of that after the first stroke, that is, only $\frac{1}{4}$ of the original density: continuing this operation, it follows that the density of the remaining air will be $\frac{1}{8}$ after 3 strokes of the piston, $\frac{1}{16}$ after 4 stroks, $\frac{1}{32}$ after 5 strokes, and so on, according to the powers of the ratio $\frac{1}{2}$; that is, such power of the ratio as is denoted by the number of the strokes. In like manner, if the barrel be $\frac{1}{3}$ of the whole contents, that is, the receiver double of the barrel, or $\frac{2}{3}$ of the whole contents; then the ratio of diminution of density being $\frac{2}{3}$, the density of the contents, after any number of strokes of the piston, will be denoted by such power of $\frac{2}{3}$, whose exponent is that number; namely, the density will be $\frac{2}{3}$ after one stroke, $(\frac{2}{3})^2$ or $\frac{4}{9}$ after two strokes, $(\frac{2}{3})^3$ or $\frac{8}{27}$ after three strokes, and in general it will be $(\frac{2}{3})^n$ after n strokes: the original density of the air being 1. .

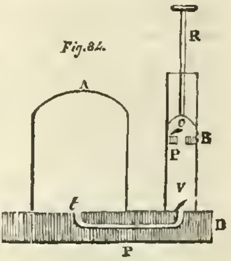
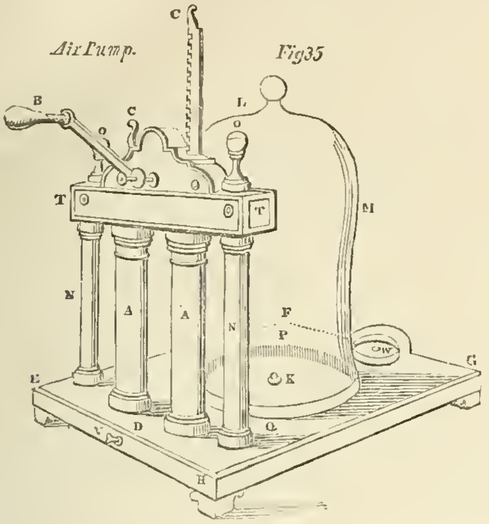


Fig. 34.

The Common Air-Pump, fig. 35, is both portable and convenient. E, F, G, H, is a square table of wood; A, A, two strong barrels of brass firmly fixed by the head bar T, T, and the pillars N, N. These barrels communicate with two tubes, as shewn in diagram 34, each having its valve opening upwards, as have also the pistons their valves. In this machine the pistons are worked by a cog-wheel fixed in the bar T T, and turned by the handle B. The teeth of the wheel work in the piston racks C, C. P Q, a circular brass plate to hold the receiver, has a hole in its centre that communicates with the piston tubes. In the piece D, at V there is a screw which closes the orifice of one pipe for the purpose of admitting the external air when required. L M is the glass receiver, out of which the air is to be exhausted, when placed on the plate P Q, which is previously covered with a wet sheepskin, or smeared with wax, to prevent the air from insinuating under the edge of the glass. When the handle B is turned, one of the pistons is raised, and the other depressed; consequently a void space is left between the raised piston and the lower valve in the correspondent barrel: the air contained in the receiver L M communicating with the barrel by the orifice K, immediately raises the lower valve by its spring, and expands into the void space, and thus a part of the air in the receiver is extracted. The handle then, being turned the contrary way, raises the other piston, and performs the same act in its correspondent barrel: while, in the mean time, the first-mentioned piston being depressed, the air by its spring closes the lower valve, and, raising the valve in the piston, makes its escape. The motion of the handle being again reversed, the first barrel again exhausts, while the second discharges the air in its turn: and thus, during the time the pump is worked, one barrel exhausts the air from the receiver, while the other discharges it through the valve in its piston. Hence it is evident, that the vacuum in the receiver of this air-pump (and the same may be said of all others) can never be perfect; that is, the air can never be entirely exhausted: for it is the elasticity of the air in the receiver that raises the valve, and forces air into the barrel; and the barrel at each exsuction can only take away a certain part of the remaining air, which is in proportion to the quantity before the stroke, as the capacity of the barrel to the sum of the capacities of the barrel, receiver, and communicating pipe. And we have shewn the ratio of exhaustion, going on in geometrical progression, until the elasticity of the included air is too feeble to push up the valve of the piston, when the receiver is said to be exhausted.—The specific gravity of air may be very accurately ascertained by means of this machine, and the method is as follows: To the neck of a glass bottle, made in the form of a Florence flask, adapt a cap and valve opening outwards, screw it on the pump, and exhaust it to a known degree, which will be shewn by the gauge attached to the pump for that purpose; then from the weight of the bottle before and after exhaustion, we have the weight of the exhausted air; and from the ratio of the height of the mercury in the gauge to the standard altitude, we know the proportion which the exhausted part bears to the whole air originally in the vessel, whose weight is therefore known. Subtracting this weight from the weight of the vessel when full of air, there will remain the weight of the vessel itself: fill it with water, and weigh it, and subduct the weight of the vessel from this weight; the remainder is the weight of a bulk of the same magnitude with the air which fills the vessel, and whose weight was also previously ascertained. Following this method, it has been found by a mean of several experiments, that the specific gravity of air is to that of water as 1·222 to 1000, very nearly, when the barometer stands at 30 inches, and in the mean temperature of 55° of Fahrenheit's thermometer. This agrees with the result already given.—Some of the principal effects and phenomena of the air-pump are the following:—That, in the exhausted receiver, heavy and light bodies fall equally swift; so, a piece of metal and a feather fall from the top of a tall receiver to the bottom exactly together: That most animals die in a minute or two: but, however, that vipers and frogs, though they swell much, live an hour or two; and after being seemingly quite dead, come to life again in the open air: That snails survive about ten hours; efts, or slow-worms, two or three days; and leeches five or six: That oysters live for 24 hours: That the heart of an eel taken out of the body, continues to beat for a good part of an hour, and that more briskly than in the air: That warm blood, milk, gall, &c. undergo a considerable intumescence and ebullition: That a mouse, or other animal, may be brought, by degrees, to survive longer in a rarefied air, than it does naturally: That air may retain its usual pressure, after it is become unfit for respiration: That the eggs of silk-worms hatch in vacuo: That vegetation stops: That fire extinguishes, the flame of a candle usually going out in one minute, and live charcoal in about five minutes.


Air Pump. *Fig 35*

Cuthbertson's Air-Pump, is exhibited in fig. 36, with its two principal gauges screwed into their places; but these are seldom used, except when great delicacy is required; for in the common experiments one of them is removed, and a stop-screw put in its place: and when all the three gauges are used, the stop-screw B admits the air into the receiver. The dotted lines represent a transverse bar that keeps the barrels steady: N, N, are two slips of wood that keep this bar down: O, O, are screws that fix it.

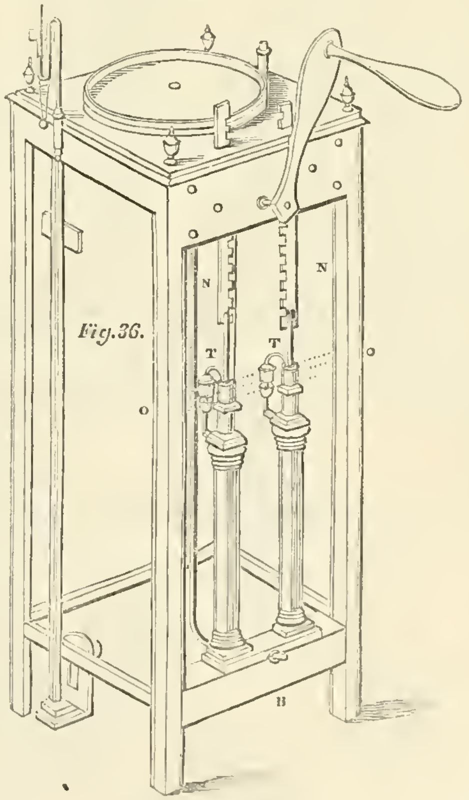


Fig. 36.

Fig. 37 is a section of one of the barrels with all its internal parts, and figs. 38, 39, 40, and 41, are different parts of the piston, proportioned to the size of the barrel, and to one another.

In fig. 37, C D represents the barrel, F the collar of leathers, G a hollow cylindrical vessel to contain oil. R is also an oil-vessel to receive the oil which is drawn, along with the air, through the hole *a a*, when the piston is drawn upwards; and, when this is full, the oil is carried over with the air, along the tube T, into the oil-vessel G. *c c* is a wire which is driven

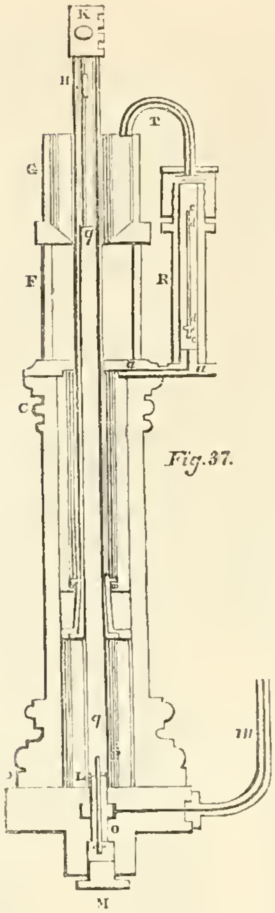


Fig. 37.

upwards from the hole *a a* by the passage of the air; and as soon as this has escaped, it falls down again by its own weight, shuts up the hole, and prevents all return of the air into the barrel. At *d d* are fixed two pieces of brass, to keep the wire *e c* in a vertical direction, that it may accurately shut the hole. H is a cylindrical wire or rod which carries the piston I, and is made hollow to receive a long wire *q q*, which opens and shuts the hole L; and on the other end of the wire O is screwed a nut, which, by stopping in the narrowest part of the hole, prevents the wire from being driven up too far. This wire and screw are more clearly seen in fig. 42 and 41; they slide in a collar of leather *r r*, fig. 42 and 40, in the middle piece of the piston. Fig. 38 and 40 are the two mean parts which compose the piston, and when the pieces 39 and 41 are added to it, the whole is represented by fig. 42. Fig. 40 is a piece of brass of a conical form, with a shoulder at the bottom. A long hollow screw is cut in it, about two-thirds of its length, and the remainder of the hole, in which there is no screw, is of about the same diameter with the screwed part, except a thin plate at the end, which is of a width exactly equal to the thickness of *q q*. The part of the inside of the conical brass in which no thread is cut, is filled with oiled leathers, with holes through which *q q* can slide stiffly. There is also a male screw with a hole in it, fitted to *q q*, serving to compress the leathers *r r*. In fig. 38, *a a a a* is the outside of the piston, the inside of which is turned so as exactly to fit the outside of fig. 40. *b b* are round leathers about 60 in number, *c c* is a circular piece of brass of the size of the leathers, and *d d* is a screw serving to compress them. The screw at the end of fig. 39 is made to fit the screw in fig. 40. Now if fig. 41 be pushed into fig. 40, this into fig. 38, and fig. 39 be screwed into the end of fig. 40, these will compose the whole of the piston, as represented in fig 42. H in fig. 37 represents the same part as H in fig. 42, and is that to which the rack is fixed. If, therefore, this be drawn upwards, it will cause fig. 40 to shut close into fig. 38, and drive out the air above it: and when it is pushed downward, it will open as far as the shoulder *a a* will permit, and suffer air to pass through. A A, fig. 43, is the receiver plate. B B is a long square piece of brass, screwed into the under side of the plate, through which a hole is drilled corresponding to that in the centre of the receiver-plate, and with three female screws *b, b, c*.—The rarefaction of the air in the receiver is effected as follows: Suppose the piston at the bottom of the barrel. The inside of the barrel, from the top of the piston to *a*, contains common air. When the rod is drawn up, the upper part of the piston sticks fast in the barrel till the conical part connected with the rod shuts the conical hole, and its shoulder applies close to its bottom. The piston is now shut, and therefore the whole is drawn up by the rack-work, driving the air before it through the hole *a a*, into the oil-vessel at R, and out into the room by the tube T. The piston will then be at the top of the barrel at *a*, and the wire *q q* will stand nearly as represented in the figure just raised from the hole L, and prevented from rising higher by the nut O. During this motion the air will expand in the receiver, and come along the bent tube *m* into the barrel. Thus the barrel will be filled with air, which, as the piston rises, will be rarefied in proportion as the capacity of the receiver, pipes, and barrel, is to the barrel alone. When the piston is moved down again by the rack-work, it will force the conical part of fig. 40 out of the hollow part fig. 38, as far as the shoulders *a a*. Fig. 42 will rest on *a a*, fig. 38, which will then be so far open as to permit the air to pass freely through it, while at the same time the end of *q q* is forced against the top of the hole, and shuts it, in order to prevent any air from returning into the receiver. Thus, the piston moving downwards suffers the air to pass out between the sides of fig. 38 and 40; and, when it is at the bottom of the barrel, will have the column of air above it: and, consequently, when drawn upwards it will shut, and drive out this air and, by opening the hole L at the same time, will give a free passage to more air from the receiver. This process being continued, the air of the receiver will be rarefied as far as its expansive power will permit. For in this machine there are no valves to be forced open by the elasticity of the air in the receiver, which at last it is unable to effect. There is, therefore, nothing to prevent the air from expanding to its utmost degree.

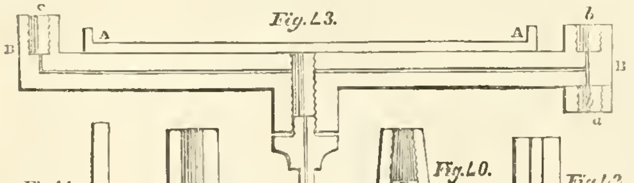


Fig. 43.

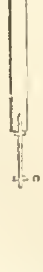


Fig. 41.

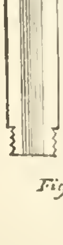


Fig. 39.

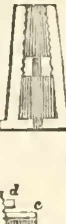


Fig. 40.

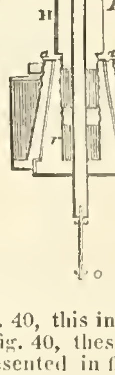


Fig. 42.

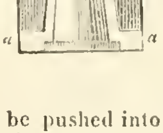


Fig. 38.

Mendelssohn's Air-Pump.—It has been objected to Cuthbertson's air-pump, that its complex structure renders it difficult to be cleaned and put together, and kept in proper order for experiments. Accordingly, Mr. Mendelssohn, a mathematical instrument-maker, residing in Great Surrey-street, Blackfriars'-Road, having reflected upon the difficulties just alluded to, was led to the construction of a more simple air-pump, capable of being easily put together whenever cleaned, and requiring that operation seldom. He rejects the tube, in common air-pumps, leading from the valves to the receiver, together with the cock that shuts this pipe: the receiver is put immediately upon the valves which are in the top of the barrels; and the rack-work and pinion being underneath, the whole instru-

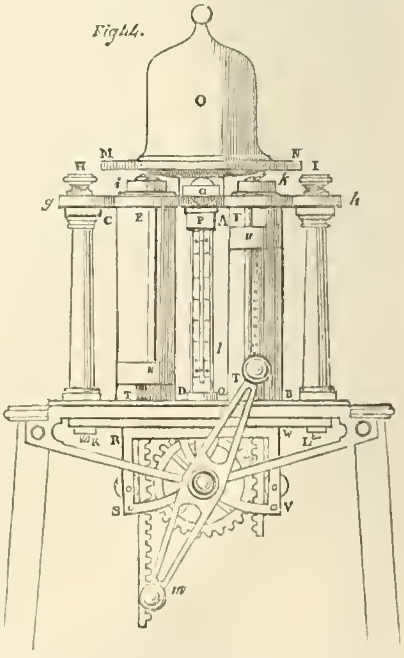


Fig. 44.

ment is inverted. In fig. 44 you have a full sight of Mendelssohn's air-pump, wherein AB, CD, are cylinders of glass, ground and polished inside. E and F, valves allowing the cylinders to communicate with the receiver O, through two very short canals *ab*, *cd*, fig. 45, and the cock G. Two other valves that open into the atmosphere, are within the covers *i* and *k*, as may be seen in fig. 45, where *e* represents one of them. MN, the receiver plate. PQ barometer gauge. HK and IL, brass pillars that support the whole. RSVW, the usual rack-work, with a double winch *lm*. The whole instrument is fixed upon a mahogany table. RS, WV, support the racks and the diagonals, on which the pinion of the cog-wheel moves.—To shew how this pump acts, it will be sufficient to explain the action of one cylinder, because the other is in all parts like it. E is a conical metallic valve, from which a canal goes through the cock G up to the receiver, as is seen in fig. 45 and 46, where all the parts are marked with the same letters. ET is a steel rod going through a leather box in the piston U. The top of this rod is fixed to the valve E, and its bottom part slides in a small hole with an allowance of 0·1 inch up and downward, consequently the valve E can move no further. When the piston descends, it opens the valve by pushing the rod to the bottom of the hole. Then it slides down the rod ET, and the air from the receiver has access to the cylinder. When the piston returns, it lifts the rod ET, and shuts up the valve. Then the piston slides along the rod to the top of the cylinder, condensing the air above it, which, by the least condensation, opens a valve *e*, fig. 46, and escapes freely into the atmosphere. This last valve has neither spring nor additional weight to shut it, but shuts by its own weight, (about a quarter of an ounce,) as soon as the piston is arrived at the top of the cylinder. The cylinders are made of glass, *and the pistons of tin, so well fitted as to be air-tight, without the interposition of any leathers.* The friction of these two bodies is remarkably small; a sufficient proof that they will be durable. They possess the further advantage of being capable of standing for even six months; after which time they will serve without being cleaned or repaired, because they are not liable to be corroded by the oil which they contain, an inconvenience too general in brass cylinders. If the present pump should want cleaning, take off the top piece *gh*, by unscrewing the nuts H and I, when this piece, with all the apparatus upon it, will come off. Then each cylinder may be slid off from the piston, wiped and replaced, after having greased it inside with a little sweet oil; the top is then put in its place, and the two nuts H and I being screwed upon it, the instrument is ready. Neither racks nor pinion need to be taken out of their places, the cylinders standing above them. The cock is constructed so, that, being in the situation represented in fig. 45, the communication is open between the cylinders, the receiver, and the barometer-gauge, and, by a quarter of a revolution, the cylinders are excluded, the receiver and gauge being still left in communication. A little stopper, ground into the cock, being open, air is admitted into the receiver, if it is required. The glass cylinders, the method of the valves opening, are new; the metallic pistons, without leathering, add to their durability, and lessen the labour of pumping. In short, the whole is vastly superior to the common pump.

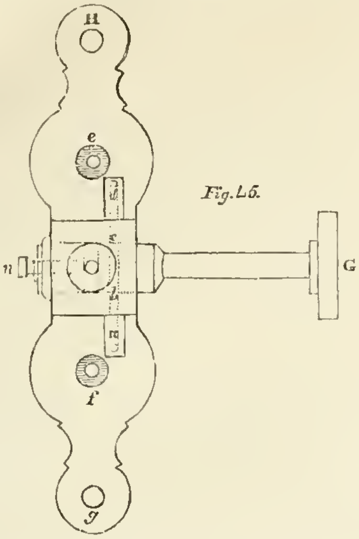


Fig. 45.

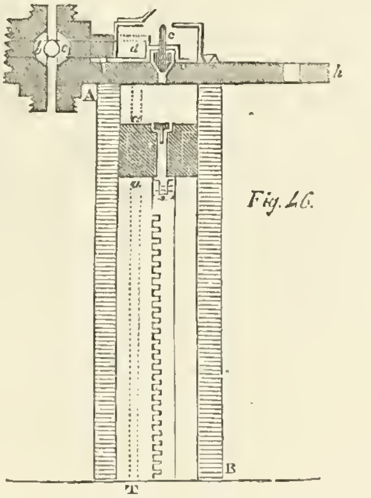


Fig. 46.

AIR LAMP, a pneumatic machine, formed by the combination of hydrogen gas and electricity, which by turning a stopcock, produces a flame that may be regulated at pleasure.

AIR GUN, fig. 47, a pneumatic instrument, which will drive a bullet with great violence by means of condensed air forced into an iron ball, B, by means of a condenser. The operation depends upon the elastic power of air, which increases in proportion to the degree of condensation imposed on it. Now the elastic power of fired gunpowder being equal to the pressure of 1000 atmospheres, or 1000 times greater than that of common air, it follows, that in order to produce the same effect with an air-gun as with a firelock, the air must be compressed into one-thousandth part of its natural bulk; and for all inferior degrees of condensation, the effect will be proportionally diminished; and as the velocities with which equal balls are impelled, are directly as the square roots of the forces acting upon them, we shall be able always to estimate the effect previous to any explosion taking place.

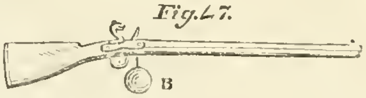


Fig. 47.

The *Condenser*, fig. 48, forces the air into the ball B; at the end *a* is a male screw, on which the hollow ball B is screwed, in order to be filled with condensed air. You set your feet on the rod *hh*, take the handle *ii* into your hand, and pump the ball *b* full of air, which the screw *a* secures till you fasten the ball to the gun for use.

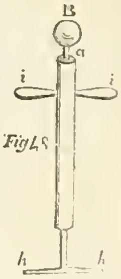


Fig. 48.

The AIR-*Dagger*, fig. 49, is thus produced. ABC is a thin partition of a room down to the floor, with an apparatus for a good convex lens, H, turned outwards into the room nearly in a horizontal direction, so as to be viewed by a person standing at F. The large concave mirror D is supported at a proper angle, to reflect upwards through H the glass in the partition B, images of objects at E presented towards the mirror below. A strong light from a lamp L, being directed on the object, and no where else, than to the eye of the spectator F, in a darkened room; it is truly surprising and admirable to what effect the images are reflected up in the air at G. Exhibitions of spectres are formed on this principle of *catoptrics*.

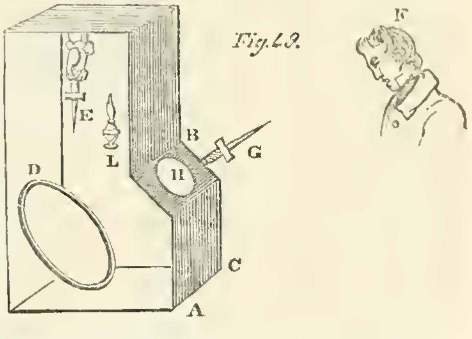


Fig. 49.

AIRA, in Botany, hair-grass.

AIRS, in the Manege, the artificial motions taught horses, as the demivolt, curvet, capriole.

AIRY, or AERIE, the nest of a hawk or eagle. AIRY *triplicity*, the three signs, Gemini, Libra, Aquarius.

AJUGA, in Botany, the bugle.

AJUTAGE, a tube fitted to the mouth of the vessel through which the water of a fountain is played: and to the different variety of form and structure of *ajutages* may be ascribed the great difference in fountains.

ALÆ, the lobes of the liver: the cartilages of the nostril.

ALABASTER, a mineral, differing from marble in being combined with sulphuric acid.

ALARM, the firing of a gun, &c. to give notice of an enemy, &c. Clocks and watches sometimes have *Alarms*, or *Alarums*.

ALARM *Bell*, that rung upon any sudden emergency: *Alarm post*, a rendezvous: *Alarm*, in Fencing, a challenge.

ALBA-FIRMA, rent paid in silver, and not in coin, which was called *black mail.*

ALBIREO, a star of the fourth magnitude, in the Constellation Cygnus.—ALBORO, a small red fish caught in the Mediterranean.—ALBUCA, bastard star of Bethlehem.—ALBUGO, a white spot on the cornea of the eye, that produces blindness.

ALBUMEN, the white of an egg; an animal or vegetable substance.

ALCE, the elk.—ALCEA, holly-hock.—ALCEDO, the kingfisher.

ALCHEMILLA, ladies' mantle; both the leaves and roots of which might be of use where mild astringents are required.

ALCHEMY, that branch of Chemistry which had for its principal objects, the transmutation of metals into gold; the panacea, or universal remedy; an alkahest, or universal menstruum; an universal ferment; and many other things equally ridiculous.—*Alchemy* took its rise among the Arabians, about the commencement of the fourth century. This delusive dream holding out a bait to avarice, soon attracted a host of followers. Intoxicated with the idea of boundless wealth, they occupied their time in searching for the *philosopher's stone*, and for a *panacea* or universal remedy, which should cure every disease, and confer the boon of immortality on the fortunate discoverer of the invaluable secret. Dioclesian, fearful that the visions of the alchemists might be realized, ordered all their books to be burnt. Roger Bacon the alchemist was excommunicated by the pope, and suffered ten years imprisonment for supposed dealing with the devil; and Paracelsus was thought to have an evil spirit in the pommel of his sword. The language of this prince of alchemists was a tissue of boasting and falsehood: he promised immortality in this world to his disciples, but his own death, in 1541, opened the eyes of his deluded followers, and blasted their sanguine hopes.

ALCOHOL, spirit of wine highly rectified: it is light and inflammable, and being highly antiseptic, is used to preserve animal substances. The spirit of wine of commerce is only an approximation to the state of alcohol, and it is found in the shops of every degree of strength above that of proof spirit, but divested of all colour. It is obtained merely by a redistillation of proof spirit;—but to free spirit of wine, as much as possible, from the water with which it is always more or less combined, and to bring it to the state of alcohol, the aid of other processes besides that of distillation are necessary. To obtain pure alcohol, Rouelles, a very able French chemist, recommends to draw off half the spirit in a water bath; to rectify this twice over, drawing off two-thirds each time; then to add water to this alcohol, which will turn it milky by separating the essential oil still remaining in it; afterwards to distil the spirit from the water, and rectify it by another distillation. Alcohol is not, however, in this state quite pure; it may yet be freed from a portion of water, by means of an alkaline salt. For this purpose, muriate of soda (common salt) may be advantageously employed, by first depriving it of its water of crystallization by heat, and adding it hot to the spirit. The subcarbonate of potash is, however, considered to be preferable. About a third part of the weight of the alcohol should be added to it in a glass vessel, be well shaken, and then allowed to subside. The salt will be found to have absorbed water from the alcohol, which being decanted, more of the salt is to be added, and the process continued until the salt falls dry at the bottom of the vessel. The alcohol must now be subjected to a final distillation in a water bath, to deprive it of the red tint obtained from the potash, as well as from the alkali held in solution. Dry muriate of lime will have the same effect of abstracting the water from the alcohol, as the alkali just mentioned. Alcohol being much lighter than water, its specific gravity is used as a test of its purity. Fourcroy considered it as rectified to the highest point when its specific gravity was 829, that of water being 1000; and this is perhaps nearly as far as it can be carried by mere distillation: by the addition of alkali, it may be brought to 813, at 60 Fahrenheit. According to the London College, it should be 815. The uses of alcohol are various; it dissolves with great facility the resins and essential oils, also camphor, bitumen, and various other substances, which renders it of great service in pharmacy, in various other arts, and to the perfumers in particular. When diluted with an equal quantity of water, constituting what is called proof spirit, it is used for extracting tinctures from vegetable and other substances; the alcohol dissolving the resinous, and the water the gummy parts. From its giving a steady heat without smoke, when burned in a lamp, it is extensively employed for heating water on the tea-table; and in many chemical operations, it is found extremely useful. It is in common use in preserving anatomical preparations, and many subjects of natural history.

ALCOR, a star in the tail of the constellation of the Great Bear.

ALCORAN, the Mahometan's Bible. *See* KORAN.

ALCOVE, in Architecture, a recess, or part of a chamber separated by an estrade or partition of columns, and other corresponding ornaments, in which is placed a bed of state, and sometimes seats to entertain company.

ALDEBARAN, a star of the first magnitude in the constellation Taurus, called also the Bull's eye.

ALDER TREE. The alder grows in wet situations; its wood is useful in machinery, as cogs for mill-wheels, pumps, water pipes, &c.; the bark is useful in tanning, and in dyeing black, by the addition of copperas.

ALE, a fermented liquor, prepared either from wheat, or rye, or millet, or oats, or barley, or the berries of the quick bean. *See* BREWING.

ALE, *To Mull.* Put a pint of strong ale into a saucepan, with three or four cloves, nutmeg and sugar to your taste: set it over the fire, but whenever it boils, take it off, and let it cool. Beat the yolks of two eggs with a little cold ale; put this mixture to your warm ale, and pour the whole several times from your saucepan into a mug. Set it over a slow fire; heat it a little; then take it off again, and heat it three or four times, till it is quite hot, and then serve it up with dry toast.

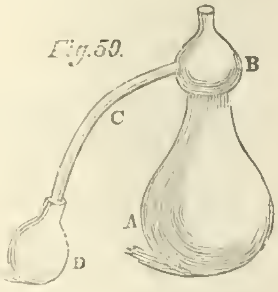
ALE *Conner*, an officer in London, who inspects the measures used in public-houses, chosen by the liverymen in common-hall, on Midsummer day. Their places are now only regarded as sinecures for decayed citizens.

ALEE, in sea language, when the helm is moved over to the sea-side, it is said to be *alee*, or *hard alee.*

ALEMBIC, fig. 50, a chemical vessel, usually made of glass or copper, and used in distillation. The bottom part A is called the *cucurbit*, or boiler; B is the head, or capital; C is a glass-tube, through which the sublimed substances pass into D, the receiver. Retorts, and the common still worm, have entirely supplanted the alembic of the alchemists.

ALEXANDERS, a plant usually found growing wild among the rubbish of old abbeys; it was much esteemed by the monks: and to the poor who use it, affords a wholesome article of food.

Fig. 50.



ALGA, in Botany, *lichen*;—ALGÆ, *flags*, one of the seven natural families into which the whole vegetable kingdom is divided by Linnæus: they are properly plants whose roots, leaves, and stems, are all one; as sea-weeds, &c.

ALGAROTH, an oxide of antimony, obtained by washing the butter of oxymuriate with pure water.

ALGEBRA, the science of Analysis, which, reasoning upon quantity or number by symbols, examines in general all the different methods and cases that can exist in the doctrine and calculation of numbers. We have no records which enable us to determine any thing with regard to the date or author of this very important science; having arisen, in all probability, like most others, by such slow and imperceptible degrees, that were we in possession of all the writings of the ancients, it would perhaps be difficult to draw a line, so as to determine the precise commencement of the algebraic art. The analytical method of investigating problems must have suggested itself very early to mathematicians. Those unknown quantities which are now represented by letters, were in the infancy of this science probably expressed by their names at full length, and every operation performed upon them, as addition, subtraction, multiplication, &c. were expressed in the same manner. But it would soon be found, that in this way a useless and tiresome repetition of the same words would occur in the most simple problems, whence we may easily conceive, how the idea of expressing quantities by letters first arose, which was by substituting the initial of the word for the word itself: the several operations were soon after represented in the same way; and thus by successive improvements arose this noble and comprehensive science, which in its present state does honour to the inventive genius of man.—Algebra is naturally divided into numeral, and specious or literal.

Numeral ALGEBRA, is that which is chiefly concerned in the solution of numeral problems, and in which all the given quantities are expressed by numbers.

Specious or *Literal* ALGEBRA, is that commonly used by the moderns, in which all quantities, whether known or unknown, are expressed by general characters, as letters, &c. in consequence of which general designation, all the conclusions become universal theorems for performing every operation of a similar nature with that for which the investigation was instituted. Every figure or arithmetical character has a determinate and individual value; as, for example, the figure 4 always represents one and the same number, namely, the collection of four units: algebraical characters, on the contrary, must be general, independent of any particular signification, and proper to represent all sorts of quantities, according to the nature of the questions to which they are applied: farther, they must be simple, and easy to describe, so as not to be troublesome in operation, or fatiguing to the memory. These advantages meet in the letters of the alphabet, which are, therefore, usually adopted to represent magnitudes in algebra. In algebraical inquiries, some quantities are assumed as known or given; and others are unknown and to be found out: the former are commonly represented by the leading letters of the alphabet, a, b, c, d, &c.; the latter by the final letters, w, x, y, z. Though it often tends to relieve the memory, if the initial letter of the subject under consideration be made use of, whether that be known or unknown: thus r may denote a radius, b a base, p a perpendicular, s a side, d density, m mass, &c. The characters used to denote the operations are principally these:

$+$ signifies addition, and is named *plus*.
$-$ signifies subtraction, and is named *minus*.
$\times$ denotes multiplication, and is named *into*.
$\div$ denotes division, and is named *by*.
$\surd$ the mark of radicality denotes the square.
$\sqrt[3]{}$ the cube root.
$=$ equality, equal to
$: \; :: \; :$ proportion.

Numbers are connected with the Algebraic symbols in two ways, *viz.*: $7x$, x^2, signifying 7 *times* x, and the *second power* of x. The figure 7 before the x is called a *co-efficient*, and shews how often x is taken; the figure 2 on the shoulder of x is called an *index* or *exponent*, and denotes the power of the letter it belongs to. If the exponent be a fraction as $x^{\frac{1}{2}}$, $x^{\frac{1}{3}}$, it denotes the □ root, or cube root of x. *Like quantities* are expressed by the same letters with the same indices, as, a, $6a$, $7a$; *unlike quantities* consist of different letters, as, a and b, or $2a$ and a^2. *Simple quantities* are composed of one term only, as, a, b, $6ab$, $7ax^2$, &c. *Compound quantities* consist of several terms, connected by the sign *plus* or *minus*; as $a+b$, $7ax-3b$, $3ab+b-e$, &c. *Positive* or *affirmative quantities* are such as have the sign $+$ before them, as, $+a$, $+6xy$. *Negative quantities* are those which have the sign $-$ before them, as, $-a$, $-6xy$. *Like signs* are all affirmative $(+)$, or all negative $(-)$. *Unlike signs* are composed of affirmative $(+)$ and negative $(-)$ signs. A *binomial quantity* consists of two terms, as, $a+b$; a *trinomial* of three terms, as, $a+b-b$; and a *quadrinomial* of four, as $a+b-c+d$, &c. A *residual quantity* is a binomial, in which one of the terms is negative, as, $a-b$. A *surd* or *irrational quantity* has no exact root, as, $\surd a$. or $\sqrt[3]{a^2}$, or $ab^{\frac{1}{2}}$. A *rational quantity* has no radical sign $(\surd)$ or index annexed to it, as, a or ab. The *reciprocal of any quantity* is that quantity inverted, or unity divided by it, as, $\frac{a}{1}$ is $\frac{1}{a}$, and of $\frac{a}{b}$ is $\frac{b}{a}$. —For the several operations in Algebra, as addition, multiplication, &c. see the several articles.

ALGENEB, a fixed star of the second magnitude in the constellation Perseus. ALGOL, a star of the third magnitude, in the same constellation.

ALIAS, in Law, a second or further writ issued from the courts of Westminster, after a *capias*, &c. has been sued out without effect.

ALIEN, in Law, a foreigner, one not within the king's allegiance.

ALIENATION, the act of making over a man's property in lands, &c. to another.

ALIENATION, in Mortmain, bequeathing lands to a body politic, by the king's license, else the property becomes forfeited.

ALIOTH, a star in the constellation of the Great Bear, much used for finding the latitude at sea.

ALIQUOT *Part*, (from *aliquotus*, any number of times,) is such a part of a number as is contained in it a certain number of times, and may therefore be otherwise considered as a divisor, or rather the quotient arising from division. *See* DIVISION.

ALKALI, in Chemistry, a particular class of salts. The alkalis at present known are these,—soda, potass, ammonia, barytes, strontia, lime, and lithium. Potass, soda, and flint, make glass: potass, soda, and oil, make soap, &c. The alkalis are incombustible, soluble in water, and possess an acrid urinous taste. They combine readily with acids, and precipitate from them the metals with which they had been previously combined. They change vegetable blues to green, red to violet, and yellow to brown. Potass and soda render oil miscible with water, and so form soap. Their peculiar crystallization when united with flint is obvious in glass.—*Potash*, a vegetable alkali, exists completely formed in the vegetable, or is produced during the operation of combustion. Potash readily combines with fat substances, and renders them soluble in water; these combinations form soap. Wine lees may be rendered almost entirely into alkali by combustion. This alkali is greenish, and is considered pure. The combustion of wine-stone also furnishes very pure alkali, but neutralized: it is known under the name of carbonate of potash, or salt of tartar. If potash and silex are fused together, the combination forms glass, but this product differs in its properties according to the respective quantities of silex and potash, of which it is composed.—*Soda*, or the mineral alkali, greatly resembles potash, and is obtained from the ashes of marine plants; as sea-weed, &c. The combination of soda, or potash, with oils or fat, forms soap; the union with potash affords soft soap, and the combination of soda with the same substances makes hard soap. Mottled soap is made by disposing the ley through the soap, or by adding to it a quantity of solution of sulphate of iron, which, by its decomposition, deposits its oxide through the soap, and gives it a variegated appearance. In some manufactories, the black oxide of manganese is made use of for the same purpose. Yellow soap is made of tallow and resin with an alkali.—*Ammonia*, or the volatile alkali, is distinguished from the former alkalis by a very sharp pungent smell, and by its great volatility. It always appears either combined, or in the state of a liquid, (liquid ammonia,) or in the aërial form, and then it is called ammoniacal gas. Its compounds are solid only when it is combined with acids.—*Barytes* has never yet been found free from all combination. It may be obtained in a state of purity by the calcination of its carbonate or nitrate, which is the heaviest mineral known. For this reason, carbonate of barytes has been termed ponderous spar. To animals it is a deadly poison.—*Strontia*, found in the state of a carbonate, that is so say, combined with carbonic acid, in a vein of lead ore, at Strontia, in Argyleshire, in the western part of Scotland, is either of a bright green colour, or transparent and colourless.—*Lime*, called also calcareous earth, is now generally considered as an alkali, as it possesses the properties of that class of substances in a striking manner, its sparing solubility in water excepted. It is found very abundantly, though never pure, or in an uncombined state. It is always united to an acid, and very frequently to the carbonic acid, as in chalk, common limestone, marble, calcareous spar, &c. It is contained in the waters of the sea, is found in vegetables, and is the base of the bones and shells of animals. Its combination with sulphuric acid forms sulphate of lime, gypsum, or plaster-of-paris. With fluoric acid it constitutes fluate of lime, or Derbyshire spar.—*Lithia*. For the discovery of the new fixed alkali, lithia, having for its base a new metal, (lithium,) we are indebted to M. Arfvresdon, who obtained it from petalite, a mineral which, by his analysis, was found to be composed of silica 80 parts, alumina 17, and the new alkali 3 parts. It is extracted from the petalite by calcining the latter, in powder, with carbonate of barytes, separating the earths, and obtaining the alkali combined with an acid. Its combinations with acids are, generally, very fusible. The sulphate and muriate liquefy below a red heat; the carbonate, when red-hot, acting violently on the platinum crucible. The former crystallizes readily, and retains no water of crystallization; nor is their solution precipitable by muriate of platinum, or by tartaric acid. The nitrate crystallizes in rhomboids, and attracts moisture; the muriate is highly deliquescent; the carbonate is with difficulty soluble in water; and when evaporated, the salt crystallizes in slender prisms; it has a greater capacity for saturating the acids than even magnesia. Alkalis are substances which have a great affinity for the acids; and the substances formed by the union of an acid and an alkali are called neutral salts, which have neither acid nor alkaline properties.

ALLEGEAS, a cotton or flax stuff, manufactured in the East Indies.

ALLEGIANCE, in Law, the tie or ligamen which binds the subject to the king, in return for that protection which the king affords the subject.

ALLERION, in Heraldry, an eagle without beak or feet, having nothing perfect but the wings.

ALLIGATION, in Arithmetic, is a rule by which such questions are resolved as relate to the mixing of divers merchandises, metals, simples, liquors, drugs, &c. of unequal prices, so as to find how much of each must be taken, according to the question: and Alligation is either medial or alternate. *Alligation Medial* is, when the price and quantities of several simples are given to be mixed, to find the mean price of that mixture. Rule:—As the whole composition is to its total value, so is any part of the composition to its mean price. Proof:—Find the value of the whole mixture at the mean rate, and if it agrees with the total value of the several quantities at their respective prices, the work is right.

Example 1. A farmer mixed 20 bushels of wheat, at 5*s*. per bushel, and 36 barrels of rye, at 3*s*. per bushel, with 40 bushels of barley, at 2*s*. per bushel.—I desire to know the worth of a bushel of this mixture?

20 × 5 = 100		As 96 : 288 : : 1 : 3.
36 × 3 = 108		
40 × 2 = 80		*Ans.* 3s.
96	288	

Exomple 2. A grocer mixes 30 lb of currants at 4*d*. per lb, with 10 lbs of other currants at 6*d*. per lb.—what is the value per lb of this mixture?

30 at 4*d*....	120
10 at 6*d*....	60
40	) 180 (4½ *Ans.*

Alligation Alternate is when the prices of several things are given, to find such quantities of them to make a mixture, that may bear a price propounded.—In ordering the rates and given price, observe,

1 Place them one under the other, and the propounded price, or mean rate, at the left-hand of them, thus,

22	18	2
	20	6
	24	4
	28	2

2. Link the several rates together by 2 and 2; always observing to join a greater and a less than the mean. 3. Against each extreme, place the difference of the mean and its yoke-fellow.—When the price of the several simples and the mean rate are given without any quantity, to find how much of each simple is required to compose the mixture.—*Rule*. Take the difference between each price and the mean rate, and set them alternately, they will be the answer required.—*Proof*. By Alligation Medial.

Example. A vintner would mix four sorts of wine together, of 18*d*. 20*d*. 24*d*. and 28*d*. per quart—what quantity of each must he take to sell the mixture at 22*d*. per quart?

Answer.			*Proof.*
22	18	2 of 18*d*. =	36*d*.
	20	6 of 20*d*. =	120
	24	4 of 24*d*. =	96
	28	2 of 28*d*. =	56
		14	)308
			22*d*.

Or thus:			*Proof.*
22	18	6 of 18*d*. =	108*d*.
	20	2 of 20*d*. =	40
	24	2 of 24*d*. =	48
	28	4 of 28*d*. =	112
		14	)308
			22*d*.

Note.—Questions in this rule admit of a great variety of answers, according to the manner of linking them.

Alligation Partial is when the price of all the simples, the quantity of but one of them, and the mean rate, are given, to find the several quantities of the rest in proportion to that given.—*Rule*. Take the difference between each price and the mean rate as before. Then, As the difference of that simple, whose quantity is given, is to the rest of the difference severally, so is the quantity given, to the several quantities required.

Example. A tobacconist being determined to mix 20 lb. of tobacco, at 15*d*. per lb. with others at 16*d*. per lb. 18*d*. per lb. and 22*d*. per lb.—how many pounds of each sort must he take to make one pound of that mixture worth 17*d*.?

Answer.				*Proof.*	
17	15	5	20 lb. at 15*d*. =	300*d*.	As 5 : 1 : : 20 : 4
	16	1	4 lb. at 16*d*. =	64*d*.	As 5 : 1 : : 20 : 4
	18	1	4 lb. at 18*d*. =	72*d*.	As 5 : 2 : : 20 : 8
	22	2	8 lb. at 22*d*. =	176*d*.	
			36 lb. :	612 : : 1 lb. : 17*d*.	

Alligation Total, is when the price of each simple, the quantity to be compounded, and the mean rate, are given, to find how much of each sort will make the quantity.—*Rule*. Take the difference between each price, and the mean rate, as before: then, As the sum of the differences is to each particular difference, so is the quantity given, to the quantity required.

Example. A grocer has four sorts of sugar, *viz*. 12*d*. 10*d*. 6*d*. and 4*d*. per lb. and would make a composition of 144 lb. worth 8*d*. per lb.—I desire to know what quantity of each he must take?

Answer.				*Proof.*	
8	12	4	48 at 12*d*. =	576	As 12 : 4 : : 144 : 48
	10	2	24 at 10*d*. =	240	As 12 : 2 : : 144 : 24
	6	2	24 at 6*d*. =	144	
	4	4	48 at 4*d*. =	192	
		12	144	)1152(8*d*.	

ALLITERATION, a rhetorical ornament, which consists of the repetition of the same letter at certain intervals; as,

> " *W*eave the *W*arp, and *W*eave the *W*oof."
> " *F*ields ever *F*resh, and *G*roves for ever *G*reen."
> " *M*ountains, ye *M*ourn in vain, *M*odred whose *M*agic song."

ALLIUM, garlic, a plant with a bulbous root, much used both as seasoning and food. When bruised and applied to the skin, it causes inflammation and raises blisters. In cases of dropsy, asthmas, and agues, it is excellent, administered as a bolus, or made into pills; or pounded in a mortar, and a spoonful taken in a glass of milk. Its smell is good in female nervous disorders. Its juice makes the strongest cement for broken glass and china: placed near the haunts of grubs, slugs, &c. in the garden, it drives these vermin away.

ALLOY signifies the production of a baser metal mixed with a finer one. In Chemistry, we apply the term to the union of different combinations of metallic matter; as, bronze, tombac, brass, white copper, &c.

ALLUVION, in Law, the gradual increase of land along the sea-shore, or on banks of rivers.

ALMAGEST, the name of a celebrated work composed by Ptolemy, and consisting of 13 books; being a collection of many of the observations and problems of the ancients, relating both to geometry and astronomy. It contains a catalogue of the fixed stars, with their places; besides numerous records of eclipses, the motions of the planets, &c.: being the first work of the kind which has been transmitted to us, and is therefore very valuable to astronomers.

ALMANACK, (said to be formed of the Arabic particle *al*, and *manah*, to count,) a calendar or table, in which are noted down all the most remarkable phenomena of the heavenly bodies for the ensuing year; such as eclipses, conjunctions and oppositions of the planets, risings and settings of the sun and moon, &c.; with the return of feasts and fasts.

Nautical ALMANACK and *Astronomical Ephemeris*, is a national almanack, begun in 1767, under the direction, and by the advice, of the astronomer royal, the late Dr. Maskelyne. This almanac, computed a few years forward, for the convenience of ships going out upon long voyages, for which it is highly useful, contains, besides most things essential to general use, and which are found in other almanacks, many new and important particulars, as, the distance of the moon from the sun and fixed stars, computed to the meridian of Greenwich, for every three hours of time, for the purpose of computing the longitude at sea.—The astronomical day is here used, which begins at noon, and is twelve hours later than the civil day, which is counted up to 24 hours; or from sun-rise in the morning to sun-setting at night, and from sun-setting at night till sun-rise in the morning.

The Construction of ALMANACS is extremely easy, if you strip them of all the absurd astrology with which such as Moore's, &c. may be crammed. The first thing to be done is, to compute the sun's and moon's place for each day of the year, or it may be taken from some ephemerides, and entered into the almanac. Next find the dominical letter, and by it distribute the calendar into weeks. Then, having computed the time of Easter, by it fit the other moveable feasts; adding the immoveable ones, with the names of the martyrs, the rising and setting of each luminary, the length of the day and night, the aspects of the planets, the phases of the moon, and the sun's entrance into the cardinal points of the ecliptic; *i. e.* the two equinoxes and the two solstices.

ALMOND, the fruit of the almond-tree, a soft and pleasant-flavoured kernel, contained in a flattish nut. Almonds are used in confectionary and cookery; they are also eaten with raisins in desserts after dinner, but they should be well chewed, as, like all nuts, every piece you swallow entire is indigestible. The oil of almonds is much used; their milk is formed of pounded almonds, loaf sugar, and water, well mixed together, and is much used in medicine.

ALMONDS, *To burn.* Put two pounds of loaf sugar and two pounds of almonds into a stew-pan with a pint of water, and let them boil over a clear fire till you hear the almonds crack; then take them off, and stir them till they are quite dry. Then put them into a wire sieve, and sift all the sugar from them. Put the vinegar into the pan again, with a little water, and boil it; put four spoonsful of scraped cochineal to the sugar, to colour it. Put the almonds into a pan; keep stirring them till they are quite dry: then put them into a glass, and they will keep for twelve months.

ALMUCANTARS, ALMACANTARS, from the Arabic *almocantharat*, are circles parallel to the horizon, conceived to pass through every degree of the meridian; being the same as the parallels of latitude.—ALMUCANTAR'S *Staff*, was formerly used at sea, for observing the sun's amplitude at rising or setting.

ALOE, a large plant, with fleshy, spinous leaves, from the centre of which, magnificent blossoms rise on stems, some twenty feet, when the tree is in a vigorous state. In Spain, where this plant is cultivated in hedge-rows, the leaves are used as scouring-paper, or their essence as soap, for it will lather in salt or fresh water.

ALOPECIA, a falling off of the hair from the head, &c. either from some defect in the nutritious juices, or by its vicious quality corroding the roots. A fresh-cut onion rubbed on the place till it be red and itch, is said to cure baldness.

ALOPECURUS, foxtail grass; one of the most productive plants of the tribe: cattle are fond of it; it grows well in moist situations, and being very early, may be cut by the middle of May. Two bushels of seed will sow an acre, with about sixteen pounds of clover.

ALPHABET, the several letters of a language, as A, B, C, &c. α, β, γ, δ.

ALPHÆNIX, in Medicine, the trivial name of white barley sugar. Perhaps the name makes it valuable! The sugar is, however, good for colds, and may be easily made by boiling common sugar till it becomes easy to crack, when you should pour it on a marble slab, greased with almond oil, and then mould it into any figures you please.

ALPHONSINE TABLES, are astronomical tables, compiled by order of Alphonsus, king of Castile.

ALPHONSIN, in Surgery, an instrument for extracting bullets out of gun-shot wounds.

ALSINE, chickweed, the leaves of which every night fold themselves up in pairs, to protect the rudiments of new shoots; thus affording a remarkable instance of the *sleep of plants.*

ALT, in Music, the high notes of the scale.

ALTAR, fig. 51, a place upon which sacrifices were anciently offered to some deity. The altars of pagans were originally of turf, but latterly of marble, stone, &c. These altars were decorated with sculptures of the respective gods to which they were dedicated. Altars were doubtless as ancient as sacrifices, Gen. chap. IV. The altar Jacob set up at Bethel was merely a stone; that of Gideon, a stone before his house; but, under Moses, the people of Israel had their *altar of incense*, that of *burnt-offering*, and the altar or table for the *shewbread.*

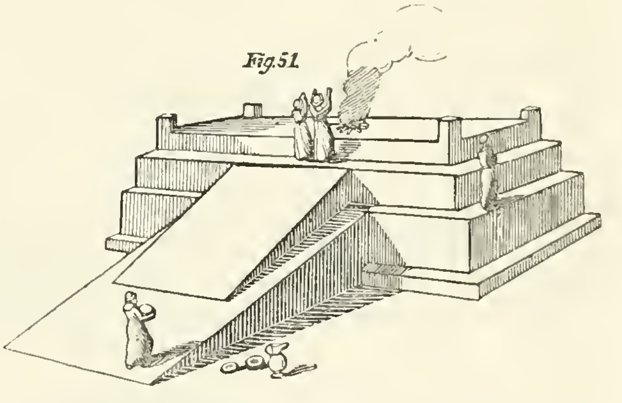


Fig. 51

ALTITUDE, in Astronomy, the distance of a star from the horizon; which may be either true or apparent, according as it is taken from the true or apparent horizon.

ALVEARIUM, a bee-hive; also the *concha*, or hollow of the outer ear. ALVEOLUS, the cells of a bee-hive. In Anatomy, the sockets in the jaws, wherein the teeth are fixed.

ALUM, a clear transparent saline matter, of a very austere and astringent nature, useful in medicine and the arts

ALTERNATION, or PERMUTATION of quantities or things, is the varying or changing the order of them. *See* PERMUTATION.

ALTIMETRY, the art of taking or measuring altitudes or heights, accessible or inaccessible, perpendicular or oblique.

ALTITUDE, in Geometry, the third dimension of a body, considered with regard to its elevation above the plane of its base.

ALTITUDE *of a Figure*, is the distance of its vertex from its base, or the length of a perpendicular let fall from the vertex to the base. Altitudes are divided into *accessible* and *inaccessible*. *Accessible* Altitude of an object, is that whose base we can have access to, so as to measure the distance between it and the station from which the measure is to be taken. *Inaccessible* Altitude, is when the base of the object cannot be approached.—There are several methods of measuring the height or altitude of bodies, *viz.* by *Geometry*, *Trigonometry*, by *Optical Reflection*, by means of the *Barometer*, &c. The instruments commonly used in measuring altitudes, are, the *Geometrical Square*, *Quadrant*, *Theodolite*, and *Harris's Telescope*, a description of each of which will be found under the respective articles.

Prob. 1. *To measure an accessible or inaccessible Altitude geometrically.*—Under this head are included all those cases, in which the calculation depends upon pure geometrical principles, and particularly on the similarity of triangles, of which we propose to give an illustration in the following examples: Let A B represent an object, of which the altitude is required. Being provided with two rods, or staves, of different lengths, plant the longest of them, as F C, at a certain measured distance from the base of the object. Then, at a farther distance, plant the second or shorter staff E D, in such a manner that the tops of the two, E and F, may be in a line with the top of the tower B. Then having measured the distance I D, as also the length E D, we shall have by similar triangles, as

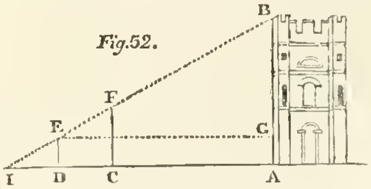


Fig.52.

$$I D : E D :: I A : A B;$$

that is, by multiplying the second and third terms, and dividing by the first, we shall have the whole altitude of the tower B A:

that is, $$B A = \frac{I A \times E D}{I D}$$

For example, suppose I A = 100 feet, I D = 8 feet, and E D = 4 feet, being the height of the staff; then $B A = \frac{100 \times 4}{8} =$ 50 feet, the altitude of the tower. When the object is inaccessible, two such operations as the above must be resorted to.

Prob. 2. *To measure accessible or inaccessible Altitudes, by means of their Shadows.*—At any time when the sun shines, plant a rod $a\,b$, perpendicularly at a, and measure the length of its shadow, and immediately after measure the shadow of the proposed object A B. Then, by similar

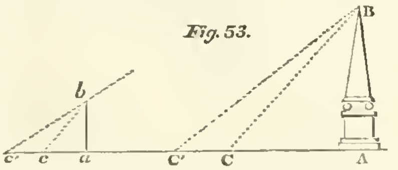


Fig. 53.

triangles, $$c\,a : b\,a :: C A : \frac{b\,a \times C A}{c\,a} = A B,$$

the altitude required. If the object be inaccessible, but still such that the difference of the lengths of its shadows, $c\,a$, $c'a$, taken at two different times, can be ascertained, the altitude may be found nearly the same as in the last example.

Prob. 3. *To measure accessible or inaccessible objects, by means of Optical Reflection.*—Place a mirror, or other reflecting surface, horizontally in the plane of the figure's base, as at C, and when the object is accessible, measure the distance C A. Now retire back in the direction A C to D, till the eye observes the top of the object exactly in the centre of the mirror, which, for the greater degree of accuracy, may be marked by a line across it. Then having measured the distance D C, and ascertained the height of the eye of the observer, it will be, from the known laws of reflection, as

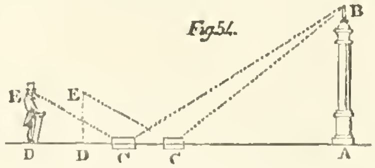


Fig.54.

$$D C : D E :: C A : \frac{D E \times C A}{D C} = A B,$$

the altitude of the object required. When the object is inaccessible, that is, when the distance C A cannot be measured, two such operations as that above must be employed.

Prob. 4. *To measure an accessible or inaccessible object, by the Geometrical Square or Quadrant. See* QUADRANT.—Having fixed the instrument at any place C, turn the square about the centre of motion D, till the top of the object B is perceived in the direction of the sights placed on the side of the square D E, and note the number of divisions cut off the other side by the plumb line E G; then having measured the distance C A, we have, by similar triangles, as

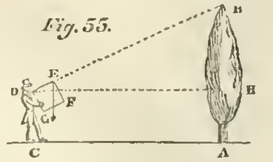


Fig. 55.

$$E F : F G :: C A \text{ or } D H : \frac{C A \times F G}{E F} = B H,$$ to

which adding the height of the observer's eye, DC, we shall have

$$\frac{C A \times F G}{E F} + D C = A B,$$ the altitude sought.

Prob. 5. *To measure an accessible object trigonometrically.*—Let A B be the object of which the altitude is required. At any convenient station C, with a quadrant, theodolite, or other graduated instrument, measure the angle of elevation A C B; then, having also measured the distance C A, we have, from the elementary principles of trigonometry, as

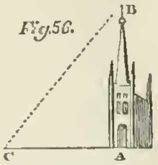


Fig.56.

$$\text{Rad.} : A C :: \text{tan.} \angle A C B : A B,$$

the altitude required; or, by logarithms, Log. A B = log. A C + log. tan. A C B — log. rad. Suppose, for example, the distance A C = 340 feet, and the angle of the elevation A C B = 34° 30′; then, by the above formula,

$$\begin{array}{lr}
\text{Log. } A C, \text{ or log. } 340 = & 2{\cdot}5314789 \\
\text{Log. tan. } 34^\circ\,30' \ldots\ldots = & 9{\cdot}8371343 \\
\hline
 & 12{\cdot}3686132' \\
\text{Log. radius} \ldots\ldots\ldots\ldots & 10{\cdot}0000000 \\
\hline
\text{Log. } B A = 233{\cdot}67 \ldots & 2{\cdot}3686132 \\
\hline
\end{array}$$

Prob. 6. *To measure an inaccessible object by two stations.*—Let A B be the object of which the altitude is required. Take the angles of elevation at the two stations D and C, & measure the distance between them. The angle D B C = the difference of the two measured angles B C A and B D A, (Euclid. prop. 16, book 1,) which angle therefore becomes known. And by trigonometry,

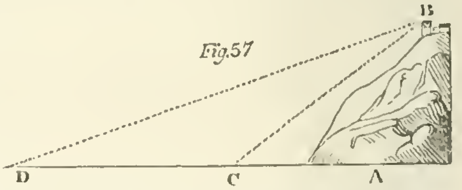


Fig.57

as $$\text{sin. } D B C : D C :: \text{sin. } C D B : \frac{D C \times \text{sin. } C D B}{\text{sin. } D B C} = C B.$$

Again, as $$\text{radius} : C B :: \text{sin. } A C B : \frac{C B \times \text{sin. } A C B}{\text{Rad.}} =$$

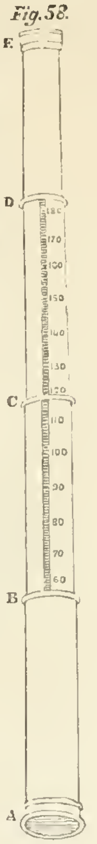
B A, the altitude required. Or substituting, in the second expression, the value of C B, we have

$$B A = \frac{D C. \times \text{sin. } C D B. \times \text{sin. } A C B.}{\text{Rad.} \times \text{sin. } D B C.}$$

Or by Logarithms.—From the sum of the logarithms of the terms in the numerator, subtract the sum of those in the denominator, and the remainder will be the logarithm of the required altitude B A.

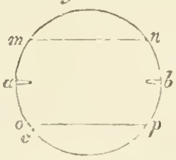
Immediately connected with angles of altitude, or horizontal angles, is the consideration of Mr. Harris's Micrometrical and Double-image Telescope and Coming-up Glass. This instrument is particularly useful at sea, or in situations when it is either difficult or inconvenient to keep an instrument in a steady position. Hence it becomes an excellent coming-up glass for ascertaining whether a ship is approaching to, or receding from, the observer. In practical astronomy it is of very extensive use, and as the minutes and seconds are, in some of the instruments, engraved on the scale, the angle is found without the trouble of reduction. The great length of the scale too, which is generally equal to the focal length of the first object-glass, renders the use of the instrument very simple. And we give this a place here, because, under the word Telescope, we shall have enough to say on the instruments of other opticians, which are purely astronomical.

Fig. 58.



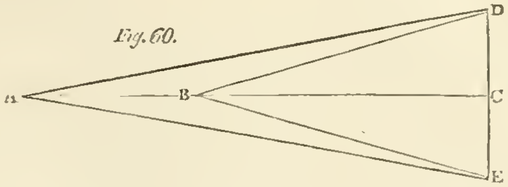
Section I. *Description of the Telescope.*—This valuable instrument, fig. 58, is divided into four parts, or drawers, of which the outer one contains a fixed object-glass at A. At C in the part CD is a moveable object-glass, which by pushing the parts BC and CD quite in, is brought into contact with the fixed object-glass at A. In this position of the drawers, distinct vision is procured by pulling out the eye-piece DE; and the magnifying power of the instrument is at its minimum or lowest degree. By pulling out the drawer CD, and afterwards the drawer BC, the magnifying power of the glass is made to increase; and when both these parts are quite drawn out, and distinct vision procured by re-adjusting the eye-piece DE, (which it will be found necessary to do every time that the position of either of the drawers is altered,) the magnifying power of the glass is at its maximum or greatest degree. In this position of the drawers two scales will be perceived thereupon; one adapted to the single object-glass above mentioned, and the other to a divided object-glass, of which a particular description will be found in the last section. By looking through the telescope, or at fig. 59, two parallel points *a*, *b*, are seen projecting into the field of view, as also a pair of fibres, *m n*, *o p*, which, with the object-glass, are essential parts of the instrument. For when it is required to measure the angle subtended by any two points of an object, in order to ascertain its distance from the observer, it is necessary that these points should be brought to coincide exactly with the steel pins, which appear as fixed points in the field of view, as before observed: which may be thus effected:—Having chosen a station which you think convenient for the observation, and two conspicuous points in the object, shut the drawers BC, CD quite in, and procure distinct vision of the points in the object, by pulling out the eye-piece DE: the points in the object will generally occupy a less space than that between the steel pins. In order that they should coincide, first draw out the part CD until they are found to do so exactly; and the milled ring at C will cut the scale at the minutes, and part of a minute, which the angle subtending the points contain. If the points do not coincide when the part CD is quite drawn out, then draw out BC until coincidence is procured; obtaining distinct vision as you proceed, and the milled ring at B will shew you the angle as before. If, when the drawers are both shut in, the points of the object occupy a greater space than the steel pins, you are too near the object, and must therefore choose two more convenient points upon it, or a more convenient station by receding from it. If, on the contrary, when the drawers are quite out, the points of the object occupy a less space than the steel pins, you are too remote from the object, and must choose either two more convenient points thereon, or a more proximate station. Observe, the drawer BC is in nowise to be touched, until C D is first quite drawn out.

Fig. 59.



Section II. *To ascertain the distance of an object either at sea or on land, by two angles and a base between them.*—When you are approaching the object, as will be oftentimes the case at sea, the first angle should be obtained when the drawers are nearly, or quite pulled out, because the angle will be increasing. But if you are receding, the angle for the contrary reason should be obtained when the object-glasses are but little apart. Let the two points of the object be called D and E, and the object C, (fig. 60,) and let the place of the first observation be called B, at which the points of the object coincide with the steel pins *a*, *b*, when the object-glasses are nearly in contact; in this case, measure a receding base to A, which should be in a straight line from the object, and not less than ⅛ part of its supposed distance, reckoning from the object-glass of the telescope; and at this second station, again measure the angle subtending the points of the object. Then to find the less distance BC;—Multiply the base by the less angle, divide the product by the difference of the angles. The quotient will be the less distance. To which adding the base, you will, if it be wanted, obtain the greater distance. If, by reason of the distance of the object, the steel pins cannot be conveniently used, the parallel fibres may be taken instead, as the ratio of the angles, determined as above, will answer the same purpose as the angles themselves, when obtained from the coincidence of the steel points *a*, *b*, with D, E, in the object.

Fig. 60.



Example 1.—Wanting to know my distance from a fortification, I found the angle subtended by two prominent points thereupon to be 180 minutes, then receding 150 yards in a straight line, I again found the angle subtending these points was 140 minutes.—Now to find the distances: We have the greater angles 180′, less angle 140′, their difference 40′.

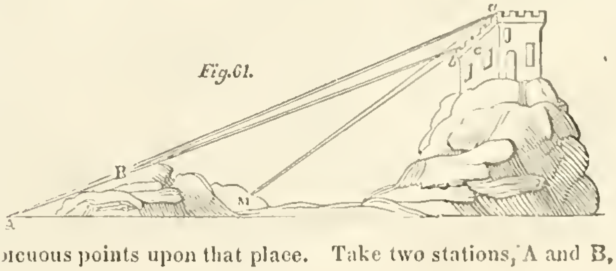
Length of the base........	150 yards.
Less angle................	140
	6000
	150
Difference of angles...4,0)	2100,0
Less distance............	525 yards.
Add the base.............	150
Greater Distance..........	675 yards.

Example 2.—Standing in shore by night towards the Lizard, I observed that the angle subtending the two lights was 40′; then standing in a direct course 1½ mile nearer per log, I again observed the angle to be 46′,—required my distance from the light at the place of the last observation. Here greater angle 46, less angle 40, their difference 6 minutes.

Length of the base	1½
Less angle	40
Difference of angles divisor.....	6)60
Less distance	10 miles required
Add the base	1½
Greater distance.................	11½

Section III.—To obtain the distance of a given point from any place, when the inequalities of the ground, or proximity to an enemy's guns, render it impracticable to measure a base from that point. Let M be the given point, and C the place whose distance is wanted, (see fig 61.) Let also *a*, *b*, be two conspicuous points upon that place. Take two stations, A and B,

Fig. 61.



beyond the reach of the guns; but in the same straight line with MC, and by measuring the base AB and the angles *a*B*b*. *a*A*b*, find as in the last section one whole distance AC. Then at the point M take the angle *a* M *b*, so will the distance MC be a fourth proportional to the angles and base, that is, angle *a* M *b*: angle *a* A *b*: A C: M C. To find M C therefore, multiply the greater distance by the angle measured at the greater distance; divide the product by the angle at the given point, and the quotient will be the distance required.

Example.—Wanting to know the distance of a point M, fig. 61, from a tower C, and circumstances preventing my measuring a base, I took two remote stations, A and B, but in the same vertical plane with M C, and distant from each other 250 yards, at which I measured the angles A and B, subtended by two conspicuous points *a*, *b*, upon the tower: the angle *a* A *b* = 60′, and *a* B *b* = 92′; and at M, I measured the angle *a* M *b* = 205′, required the distance: First angle B = 92, and A = 60 their diff. = 32′; and angle B $\frac{92\times200}{32}$ = base 719 yards A C by the last section; then angle M, angle A : : A C : M C; or 205′ : 60′ : : 719 : 210,4 yards.

Or as angle M	205′	arith. com. log.	7,68825
Is to angle A......	60′	log.........	1,77815
So is A C.........	719	log.........	2,85673
To M C........	210,4	log.......	2,32313

Working by logarithms, which in general will be found the most expeditious method.

Section IV. *To measure the height of an accessible object.*—Let B A (fig. 62.) be an accessible object; then from a point B, as near as possible to the vertical line C B A, measure the angle *a* B *b*, subtended by two conspicuous points at the summit of the object; measure also the angle *a* C *b*, subtended by the same points, as seen from another station C, and measure the base C B. Then to find the perpendicular. Square the greater and less angles, take the difference of the squares, and the square root of this difference. Multiply the greater angle by the base, and divide the product by the square root just found; the quotient will be the perpendicular height required. Or, if the Hypothenuse A C be wanted: Multiply the less angle by the base for a dividend, and divide by the square root above, and the quotient will be the answer.

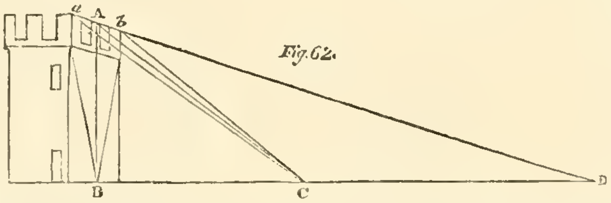


Fig. 62.

Example:—Wanting to know the height of a tower, (fig. 62,) I measure from a point B near its base, the angle subtended by two points *a* and *b* at its summit, which was 150 m. I then measured 56 yards to a point C, and again took the angle between the points, and found it 180 minutes.

Here the greater angle....	180	The less angle....	105
	180		105
	14400		525
	180		1050
Sqr. of Gr. angle..........	32400		11025
Sqr. of less angle	11025		
Diff. of square............	21375	(146, 2 root	
	1	Greater angle.....	180
		Base	56
	24)113		
	96		1080
			900
	286)1775		
	1716		146,2)10080
	2922)5900		Perpen. 68.95
	5844		
	56, &c.		

It is obvious that this question, even in its most simple state, may be more readily performed by logarithms.

Thus, greater angle........	180	Log.	2,25527
			2
Square of gr. angle........	32400		4,51054
Square of less. angle	11025		
Diff. of Squares	21375		
Less. angle...............	105	Log.	2,02119
			2
	11025	Log.	4,04238
Diff. of Square Log......	2)4,32990		
Square root Log.	2,16195	ar. co. log.	7,83505
Logarithm of Gr. angle..........			2,25527
Logarithm of Base..............			1,74819
The perpendicular required	68,95	Log.	1,83851

Section V. *To ascertain the distance of a known magnitude.*—Let the distance between two points D and E (fig. 60.) of a distant object be known, then by choosing a station at B, so situated that the line joining these points may be at right angles to the axis of the telescope, and measuring the angle subtending these points as seen from B, we have, for ascertaining the distance of B, from the object, the following Trigonometrical Theorem: Tangent angle B : D E : : radius : the distance. Or to the Cotangent of angle B add the logarithm of D E; the sum, rejecting 10 in the index, will be the logarithm of the distance.

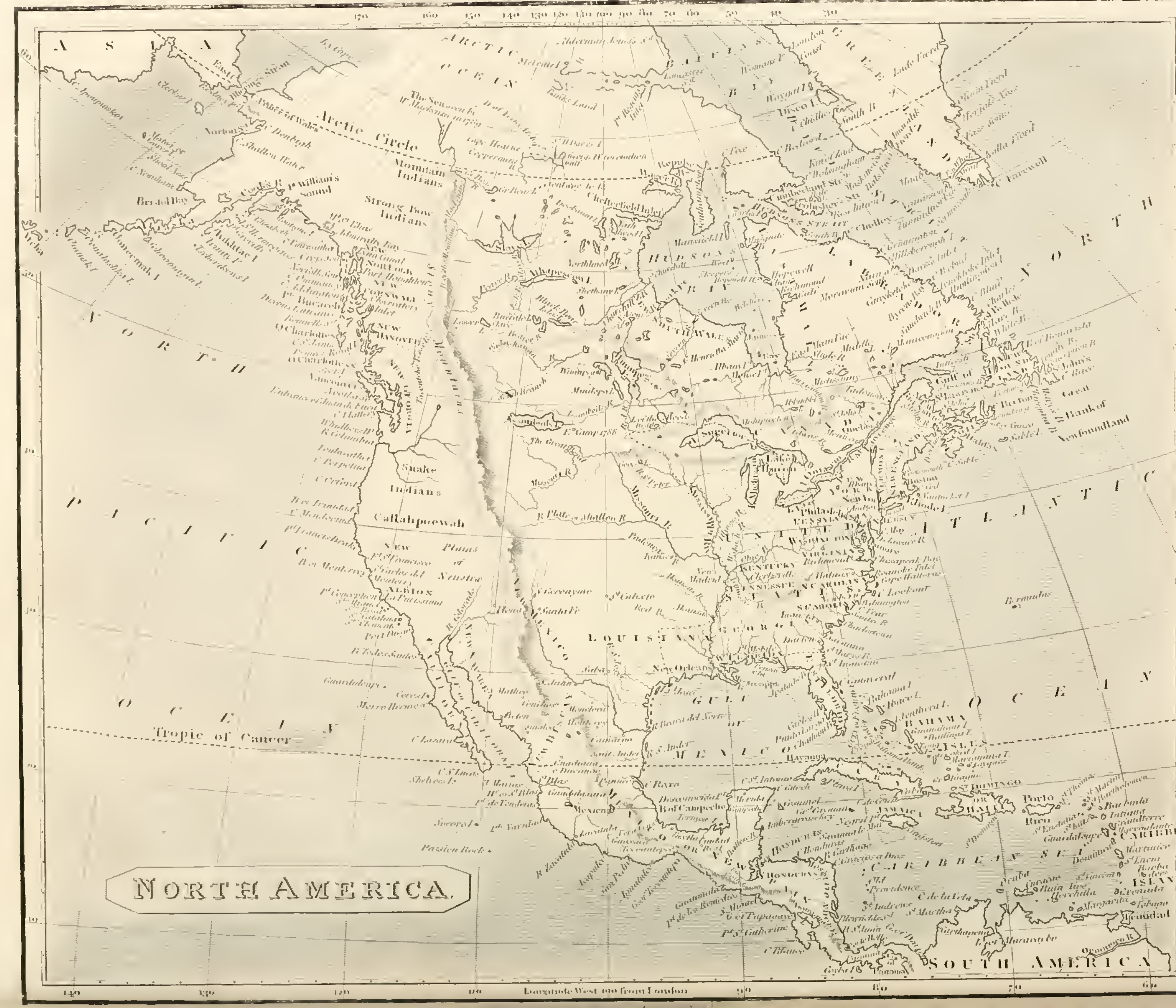
Example.—Seeing a ship, the height of whose main-top-gallant mast head I take to be 150 feet, or 50 yards above the water's edge, I measure the angle subtended by these points, which is 43 min.—what is my distance from her?

Here angle B......	43′	Log. Cotangent	11,90278
Dist. of points......	50	Log............	1,69897
Distance...........	3997	Log............	3,60175

So my distance from the ship is 3997 yards, or 2¼ miles nearly.

Note.—After any given interval of time you may again observe whether the points are still in coincidence: if they are, the angle remaining unaltered shews clearly, that you are both sailing at the same rate if they do not still coincide; but the steel pins occupy a greater space than the points of the ship, the angle is decreasing, and you are dropping astern; but if the points of the ship occupy a greater space, you are coming up; and may, by another observation, determine at what rate. It may be necessary here to observe, that any two points may be taken for the above purposes, provided that their distance from each other is known, and their position such, that a line joining them may be at right angles to the axis of the telescope: for which reason the points upon the masts are to be preferred to those upon the yards, being less liable to vary their position.

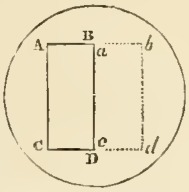
Section VI.—It has been hitherto supposed that the single object-glass, with the steel pins, has been used in the observation; these however are liable to an inconvenience at sea; which, although it will be overcome by practice, may not here be overlooked: for when the two points of an object are brought into contact with the steel pins, the slightest motion or tremor of the hand will again displace them, and thereby render the observation, to a beginner especially, exceedingly tedious. These inconveniences may however be entirely obviated, by substituting the divided object-glass for the single moveable one at C in the instrument; and of which the following description is submitted to notice:—The divided object-glass consists of two semilenses, whose centres are invariably distant; when it is used, by looking through the telescope, two images of the object will appear upon the field of view, which by turning the telescope gently upon its axis, will appear to revolve about each other, being quite separate,



NORTH AMERICA.

if the object does not occupy more than one-third of the field of view; but, if otherwise, the images will overlap each other in a greater or less degree. Now, suppose the object A C B D, fig. 63, to be that under observation: then, if it be required to measure the angle subtended by the part A B of the object; first draw out C D, and afterwards, if necessary, the part B C, until the points *a* and *b* of one image exactly coincide with their corresponding point A and B of the other; and the index at C or B will point out the measure of the angle subtended by these points, upon the scale for the divided object-glass. If it were required to measure the angle subtended by the points B and D of the object, it would be evidently necessary to adjust the drawers, until the point *d* coincided with its corresponding point D. It will be found, that the images have different degrees of distinctions in different parts of the field; but it will be easy to make any part of an image more distinct than another, by changing its place in the field of view, and it will contribute to the accuracy of the observation, to bring the part of the image where the contact is to be observed, into the centre of the field, it being the part where the points of contact will be most distinctly seen. As a coming-up glass, the divided object-glass possesses an eminent superiority over the single one, by reason of the steadiness with which the observation may be made: for any two points being brought into contact, neither the tremors of the hand, nor even the motion of the vessel, will displace them; its use may be illustrated as follows: When a vessel is seen at a distance, it subtends a certain angle at the eye of the observer; if the distance increases, the angle will, of course, proportionally diminish, and the contrary. Now, if the vessel be viewed through the double-image telescope, and if the drawers be adjusted until the two images of the whole, or a part of the vessel, be brought into contact; the index will cut the scale in the angle subtended by the whole, or that part. If the images continue in contact, the distance of the vessel must have remained the same; but if the images have separated from each other, the vessel must be receding from the observer, and the proportion of the distances may be found by again bringing the images into contact, finding thereby the angle anew, and thence, by the 2d or 5th section, the distance at the time of each observation. It may be also observed, that the object, or portion of an object, whose angle is to be measured by means of the double-image telescope, should be chosen as luminous as possible; or, when it can be obtained, it should be a dark object with a light ground, such as the top of a building with a sky behind it: and in measuring inaccessible distances, as by section 2, the two images of the object D E should appear separate, but as near as possible, when the observer is at B, and when the object-glass and semi-lenses are in contact.—To facilitate the observation, this instrument is sometimes constructed with one drawer instead of the two, B C, C D, which, with the eye-piece, is adjusted by means of a rack and pinion upon each, the telescope being supported upon a stand; and when it is intended to change the object-glasses in the instrument thus constructed, it will be necessary, in order to come at the moveable object-glass, to screw off the top part of the instrument about 4 inches below the principal object-glass, having first adjusted the drawer quite in. And to correct any variation which may occur in the sight of different observers, an adjustment to the stop is fixed upon the pipe containing the two first eye-glasses, by moving which, until the points and fibres are seen the most distinctly, the instrument will be adjusted to the particular eye of the observer.—We have here given a brief description of this valuable instrument, its uses and qualities, and trust, that upon trial, it will be found to exceed, rather than fall short of, the properties attributed to it. The examples which are introduced in the different sections for the purpose of illustration, as well as the rules for working them, are applicable to either the single or divided image glass; and the principles upon which these rules, as well as the instrument itself, are constructed, are demonstrated at large in Dr. Brewster's Treatise upon New Optical and Philosophical Instruments.

Fig. 63.



Analogous to the foregoing, is the *Micrometrical Telescope*, which possesses all the advantages of the common telescope, is of great use for military and naval purposes, and likewise in surveying, and practical astronomy. The object of it is to measure angles and distances, which it does with great facility and accuracy. From the nature of its construction, it has also the properties of an excellent microscope. This ingenious instrument, being formed with sliding tubes, is very portable and convenient, and will be found extremely useful to military gentlemen and others, who may wish to ascertain distances without a more cumbersome apparatus.—Those of our readers who already possess achromatic telescopes, may have them converted into this instrument at a trifling expense.

ALYSSUM, madwort, a plant which was believed to have the property of curing madness.

AMABYR, an old British word, signifies, "*the price of virginity*," and expresses a barbarous custom which formerly prevailed in several parts of England and Wales, being a sum of money paid to the lord, when a maid was married within his lordship.

AMADOW, the pyrotechnical sponge, a kind of black tinder, made of a species of fungus or mushroom that grows upon the bark of trees in Germany.

AMALGAM, mercury united with some metal.

AMAUROSIS, a deprivation of sight, the eye remaining fair, and seemingly unaffected.

AMBE, an instrument used by surgeons for reducing dislocated bones.

AMBER, a bituminous substance, highly electric, and much used in medicine and the arts.

AMBERGRIS, or Gray Amber, is found swimming in the Atlantic; on the coast of Brazil; in the East Indian archipelago, &c. and sometimes in the belly of the spermaceti whale.

AMBIENT, a term applied to fluids that encompass others on all sides, as the air, a flame, &c.

AMBIT, in Geometry, the perimeter of any figure.

AMBLE, the pace of a horse when his two legs on one side move at the same time.

AMBUSCADE, a place where soldiers may lie concealed till they find an opportunity to surprise the enemy.

AMERCEMENT, in Law, a pecuniary punishment, imposed on offenders at the mercy of the court.

AMERICA, the largest of the four quarters of the globe, extends from the 56th degree of south latitude to the unknown regions within the arctic circle, and from the 55th to the 165th degree of west longitude. Its length is nearly 10,000 miles, and its medial breadth about 2000. America was discovered by Christoval Colon, (or, as the Latin writers of the time call him, Christopher Columbus,) in four successive voyages: on the 12th of October, 1492, he discovered the isle of San Salvador; in 1493, the Caribbee Islands; in 1498, the continent adjacent to the Orinoco; and in 1502, a great part of the continent around Porto Bello. Amerigo Vespucci, a Florentine, and a man of science, who accompanied Colon, published the first account of the New World, and thus gave it his own name corrupted into America.—America is divided into two parts, called North and South; and these are again subdivided into separate kingdoms and states.

North America is bounded on the north by the unexplored Arctic regions; on the west, by the Pacific Ocean and Behring's Strait; on the south, by the Gulf of Mexico; and on the east, by the Atlantic Ocean; that is to say, from 7½° north latitude, to 72° north latitude; or 64½°, being 3870 geographical miles; and from 55° to 165° west longitude, or 110°, being 3300 geographical miles, taking the number of miles at thirty in a degree of longitude at latitude 60°. The climate is very various; but in general, summer's heat and winter's cold are more intense than in most parts of the continents of Europe and Asia. The centre of North America is a vast fertile plain, watered by many rivers. The seas adjacent to North America are Baffin's Bay, Hudson's Bay, the gulfs of California and Mexico, and the St. Lawrence. The lakes are, Superior, Michigan, Huron, and Slave lake, between Canada and the United States. The rivers are, the St. Lawrence, the Missouri or Mississippi, Rio-Bravo, the Ohio, Red-River, and the Mackenzie. The mountains are, the Stony Mountains, the Apalachian Chain, the Iron and White

Oak Mountains. These ridges are usually marked on good maps.

South America extends along 66° of latitude, or 3960 geographical miles; and its breadth is 48°, or 2880 geographical miles, reckoning from Cape Blanco in the west, to Cape St. Roque in the east. Many parts of this vast continent are aboriginal and impenetrable forests, vast saline plains, regions flooded by inundations; and from the summits of the Andes, covered with eternal snow, to the torrid plains on the sea-coast, every climate is perceptible. The lakes are, Maracaybo in the north, 100 miles in diameter; Parima is 100 miles long, and 50 broad; lake Titicaca is in Peru; and in Chili is the lake of the Tehuels. The rivers are those of the Amazons, or Maranon, the largest river in the world; Rio de la Plata; the Orinoco; the Magdalena, running north to the Caribbean sea; St. Francis in Brazil, &c. The mountains are the Andes, 20,280 feet above the level of the sea, and 4,600 miles long. A chain proceeding from west to east, at nine or ten degrees north of the equator. The mountains of Parima, or the chain of the Cataracts of Orinoco, from 3° to 7° north latitude. The chain of Chiquitos, between 15° and 20° of south latitude. Between these three great ridges, three immense valleys open to the east, but shut to the west, extending from the Andes to the shores of the Orinoco, Amazons, and Buenos Ayres. Of these plains, that of Amazons is covered with impenetrable forests; while those of Orinoco, and Pampas, or Buenos Ayres, are grassy valleys or savannas, so level, that for 800 square leagues, no elevation or inequality can be seen.

North America.—The United States of America occupy that portion of North America which lies between the Mississippi on the west, the lakes and the St. Lawrence on the north, and the Atlantic and the Gulf of Florida wash their eastern and southern extremities. The population is above 12 millions, including 1,200,000 slaves! And it is inferred, that the population of this country doubles itself every twenty years.

States.	*Relative Situations.*	*Towns.*
Main	N. to S.W.	Portland.
New Hampshire		Portsmouth.
Vermont, *west* of New Hampshire		Bennington.
Massachusetts		Boston.
Rhode Island		Newport.
Connecticut		Newhaven.
New York		New York, Hudson's River.
New Jersey		Trenton, on the river Delaware
Pennsylvania, *west* of New Jersey		Philadelphia, on Delaware.
Delaware		Dover, on Delaware Bay.
Maryland		Annapolis, or Chesapeak Bay.
Territory of Columbia		Washington, on riv. Potomac
Virginia		Richmond, on James's River.
North Carolina		Newbern, Nase River.
South Carolina		Charleston.
Georgia		Savannah, on Savannah Sound

Back Settlements.

Indiana	N. to S.W.	Clarksburg.
Franklinia		Knoxville, on river Tennessee.
Western Territory	N. to S.	Clarksville, on the river Ohio.
Kentucky		Lexington.
Tennessee		Nashville, on Cumberland Riv.

The Aborigines (wild and rude tribes of savages) occupy all the part between Georgia and the river Mississippi.—The government is vested in a president, chosen every four years, and two councils or senates; the members of the superior senate being chosen every sixth year, and those of the inferior every second year. The president is a *democratical king*, in whom the executive government is vested. Each province has its government or senate, consisting of a house of representatives. The president commands both the army and the navy; the former is inconsiderable, but the latter augments with suspicious rapidity. The revenue is about twelve millions of dollars, the expenditure about ten millions; the national debt is seventeen millions sterling. The Americans are cold and reserved, evincing a contempt of strangers, and excessively bigoted in religious matters, though their tenets are as various as schismatical invention can render Christianity. The colleges and academies are numerous, but the American booksellers reprint twenty British works for one originally transatlantic. The chief cities are, New York, Philadelphia, Charleston, and Baltimore, for commerce; and Boston for its fanatical spirit. New Orleans is situated on the Mississippi; Norfolk is the chief port of Virginia. The inland navigation of the United States is very superior, but the public roads are indifferent. The manufactures are in general in their infancy, though in some things the Americans have made considerable progress, as must be evident from the population being chiefly composed of Britons and Germans, the two most persevering mechanical nations of Europe. The climate is remarkable for sudden transitions from heat to cold; but the seasons in general correspond with those in Europe; and the soil is for the most part fertile. Three parts in four of the population are directly or indirectly connected with agriculture, which therefore thrives well; and while the southern states resemble our West India plantations, the orchards and corn-fields in the northern states bear a great resemblance to those of Lothian and Worcestershire. The rivers are, the Mississippi, the Ohio, the Illinois, the Uisconsin, the Chipaway, St. Croix, the Great and Little Miami, the Wabash, the Great Kennaway, Kentucky, the Green River, the Cumberland, and the Tennessee. Into the Atlantic flow St. Croix, Penobscot, the Kennebec, the Saco, the Merimac, the Connecticut, the Hudson river, the Delaware, the Susquehanna, the Potomak, James's river, the Shenandoa, the Black Water and Staunton, the Pedee, the Santee, the Savannah, and the Attamala. The lakes, Cedar, Little Winnepeg, and Leech, Champlain, Lake George, Oneida, Cayuga, and Sennaka. The others we have mentioned. The chief mountains are, the Apalachian, the White and Green mountains in the northern districts, the Land's Heights, the Savage and Bald mountains, and the Allegany or Blue mountains. The aboriginal forests are large and numerous; and the lake of the Dismal Swamp, 150,000 acres in extent, is covered with trees of prodigious height, choked up with brushwood, so as to render the swamp impervious. Bears, wolves, deer, and other wild animals, roam undisturbed here. The lake or marsh of Onaquafenoga, in Georgia, is 300 miles in circumference, and contains many fertile islands, one of which, called Paradise, or the Happy Isle, is inhabited by a peculiar race of Indians, whose women, from their incomparable beauty, are called the daughters of the sun. The islands belonging to the United States, are Long Island, a few insular strips of land near the shores of North Carolina, with others scattered along the coast, and in the various bays and lakes.

The Spanish Dominions in North America.—These dominions are 2200 miles in length, and about 460 in breadth; and the population amounts to eight millions, of whom four millions and a half are Indians, two millions and a half a mixed race, and one million of Spaniards. And we might divide them into East and West Florida, California, and New and Old Mexico: thus, 1st. *On the Pacific arc,*

Divisions.	*Rel. Sit.*	*Chief Towns.*
California, *n. w.*		St. Juan.
Sonora	N. to S.E.	Mazatlan.
Guadalaxara		Guadalaxara, on Rio Grande.
Valladolid		Valladolid.
Mexico		Mexico, on the lake of Mexico.
Puebla		Tlascalla.
Oaxaca		Oaxaca, on Rio Verde.
Guatimala		Guatimala.
Nicaragua		Fort St. Juan, on Rio de St. Juan.
Costarico		Cartago.
Veragua		St. Yago.
Panama		Panama, on Panama bay.

2dly. *On the Atlantic arc,*

New Leon	N. to S.E.	New Santander.
Vera Cruz		Tampico, on Rio Tampico.
Tabasco		Villa Hermosa, on Rio Tabasco.
Yucatan		Salamanca.
Verapaz		Santa Cruz, on the gulf of Dulce.
Honduras		Truxillo.

3dly. In the Interior are,

New Mexico, proper	N. to S.	Santa Fé, on Rio Bravo.
Durango..........		Nombre de Dios.
Zacatecas..........		Zacatecas.
Guanaxuato.......		Guanaxuato.

The soil, produce, and climate of these dominions are thus described: — Extensive savannas feed numerous herds of cattle; the mountains abound in the precious metals; the climate is singularly diversified between the tropical seasons and rains, and the temperature of the southern, and even middle countries of Europe. The climate has a ruling influence over the diseases of these regions, among which, the yellow-fever is one of the most fatal, but it usually confines itself to sea-ports. The soil is often a deep clay, surprisingly fertile, and requiring no manure, save irrigation; but the division of land is far more unequal than in Europe, yet agriculture flourishes. The chief products are wheat, cotton, indigo, tobacco, cochineal. California is famous for fish, and a pearl fishery; and in the centre of this peninsula is a plain of rock salt, as firm and pellucid as crystal.—The province of Valladolid, the most delightful of these fertile regions, produces the pine-apple, pomegranate, fig, citron, lemon, orange, and cocoa-nut trees, sugar canes, indigo, jalap, &c. And its chief ports are Vera Cruz and Acapulco.—The kingdom of Mexico is by far the most important of these settlements, as its capital, Mexico, is the chief city of Spanish America. The population of this city is 150,000 inhabitants, and it is the seat of a vast commerce between Vera Cruz and Acapulco. Mexico is situated in a vast plain, 7475 feet above the level of the sea. The religion is the Roman Catholic, and one-fifth of the Spaniards are ecclesiastics, monks, friars, and nuns. The inquisition ruled here with fanatic fury in former times. In Mexico there is an enclosure between four walls, filled with ovens, into which are thrown the unhappy victims of the inquisition, condemned to be burned alive! There are in Mexico no remains of what our historians have fabled, and its chief remaining antiquities appear to be earthenware, ruins of dykes and aqueducts, some colossal statues, hieroglyphical pictures, weapons, and knives of sacrifice. The government of Mexico is the chief of Spanish America, and it is extended over a territory equal to an European empire. The sovereign's power extends to the patronage of all the churches, the disposal of lucrative offices, monopolies, connivances, presents; and his court, upon a regal plan, is hemmed in by horse and foot guards, while his household and numerous attendants swell the pageantry. Guatimala is ruled by a president, who is also captain-general of the troops. Each of the interior provinces has its president. The army has been computed at 40,000 men; but it is difficult to speak near truth on the revenue, and several other matters of general geography, belonging to the Spanish dominions in North America. The independence of Mexico has been formally acknowledged by Great Britain. This country is still partly ruled as formerly, but it seems probable that its government will be assimilated to that of the United States. The chief towns are, Tasco, Guanaxuato, Guatimala, Xalappa, Merida, Santa Fé, Panama, Porto Bello, and Acapulco. Tasco, situated 6000 feet above the level of the sea, is the seat of the noted mines of Moran and Oyamel. The surrounding region is covered with oaks and pines, and the crops of wheat and barley are very abundant. But Guanaxuato boasts the richest silver mines in the world; that of Valencia yielding its proprietor a revenue of £130,000 annually, and produces above half a million sterling. This mine is 280 fathoms in depth. In 1773, Guatimala was destroyed by an earthquake, and 8000 families perished; but the new city is well peopled. Xalappa is romantically situated in a fine climate, about the middle of Vera Cruz; and near it the snowy peak of Orizala, or the star mountain, rises to the sublime height of 17,390 feet above the level of the sea. In Merida, the capital, resides the governor of the province of Yucatan. Another governor resides at Santa Fé. Panama has a rich pearl fishery, and is the noted resort of merchant vessels. Porto Bello is a fine harbour, and is celebrated for its fairs, which are much frequented by merchants. And though the climate of Acapulco be sultry, it engrosses the chief Indian trade over the Pacific.

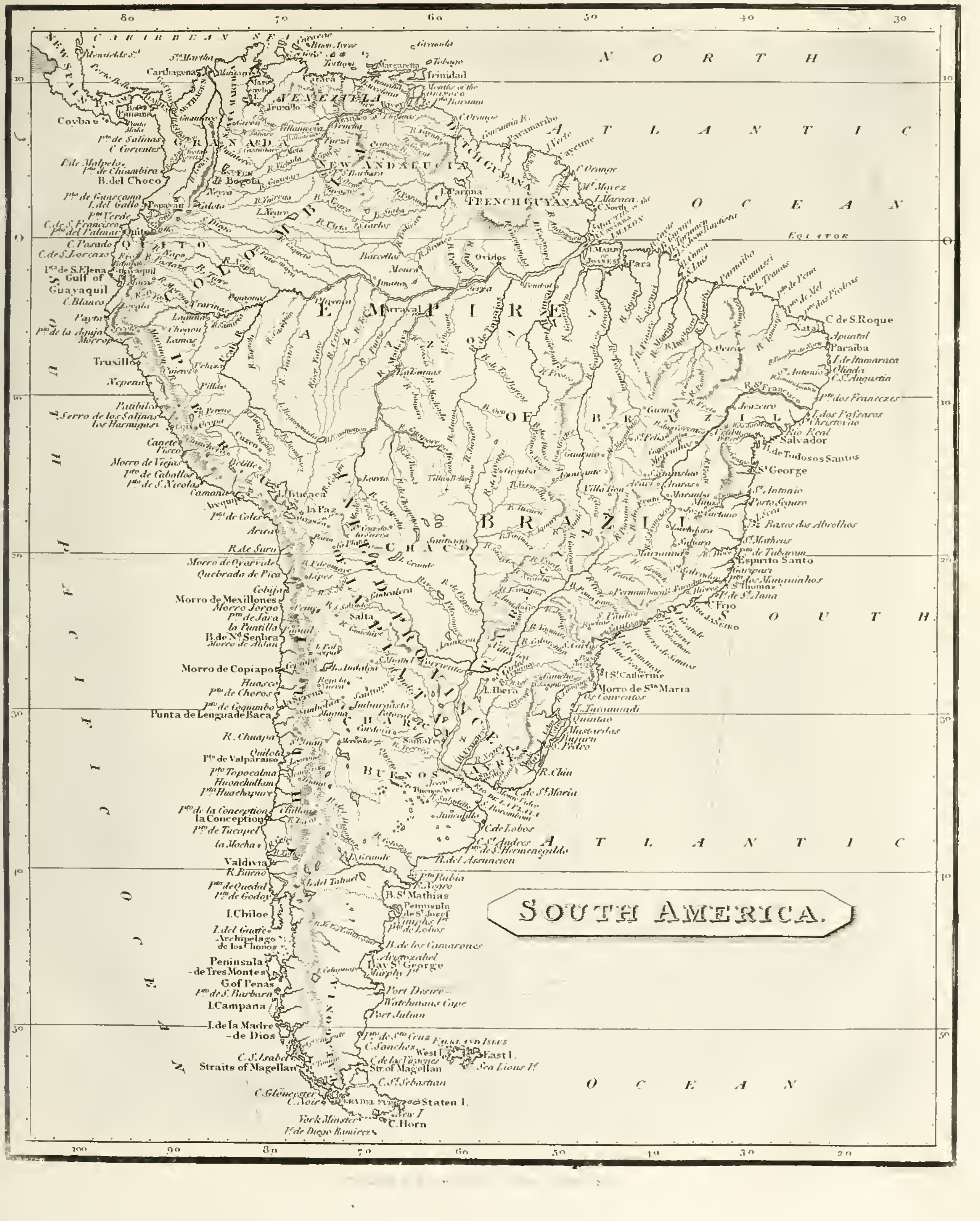
The British Possessions: Canada, &c.—Canada extends from the Gulf of St. Lawrence to Lake Winnapeg, 1400 miles; and its average breadth is about 200 miles. This country is in general mountainous and woody; but in Upper Canada there are savannas and plains of great beauty. In the lower province, the soil is a loose, black, fertile mould, of a foot thick, resting on clay. The climate is salubrious, but cold during winter, which continues eight months severe. Canada exports furs, hides, timber, fish, potash; and receives spirits, wine, tobacco, sugar, salt, and manufactured goods, chiefly from England. The established religion is the Protestant, superintended by the Bishop of Quebec. But as the French were the first possessors of Canada, there are many Catholics. The Protestant clergymen are 12, the Catholic 125, from which it appears in what ratio the Catholics outnumber the Protestants. The chief towns are, Quebec, Sorelle, Trois-Riviers, Montreal, and Kingston. Quebec, upon the north of the river St. Lawrence, is immortalized by the death of General Wolfe. The population amounts to 10,000 souls; and the adjacent country presents much sublime and picturesque scenery. From December to April, the river is frozen over here. Montreal, 150 miles above Quebec, has about 7000 inhabitants, and its chief traffic is in furs, which the traders purchase from the Indians. Kingston is situated on the Lake Ontario, at the grand egress of the river St. Lawrence. Trois-Riviers is the grand resort of the Indians, and its population is not more than 1500 souls.—The island of Newfoundland, about 320 miles in length and breadth, has, as its chief towns, St. John, Placentia, and Bonavista. The population does not exceed a thousand families during the winter. The celebrated station on the banks of Newfoundland is more than 400 miles in length, and about 140 in breadth; the water being from twenty-two to fifty fathoms, with a great swell, and frequently a thick fog. The chief fishery begins on the 10th of May, and continues till the end of September; the greatest number of cod-fish taken by a single fisherman is about twelve thousand, the average is seven thousand. The largest fish are each about four feet three inches in length, and weigh about forty-six pounds. Upwards of 500 English vessels frequent these banks, and about the same number of Americans and French.—New Brunswick is separated from the province of Main, belonging to the United States, by the river St. Croix; and the Apalachian mountains pass along the north-west of this province. The capital is Frederick Town, on the river St. John, which affords a common and near route to Quebec. Some settlements, commanded by Fort Howe, have been established in the bay of Fundi.—Nova-Scotia is a province on the east of Canada, and south of the river St. Lawrence. New Brunswick is the more northerly, Nova Scotia the more southerly. And the Bay of Fundi, between New Brunswick and Nova Scotia, extends fifty leagues inland, the ebbing and the flowing of the tide being from forty-five to sixty feet. Halifax, the capital of Nova Scotia, contains 15,000 inhabitants; and the Bay of Fundi is remarkable for its sublime and picturesque scenery. The island of Cape Breton, close to Nova Scotia, has a cold and foggy climate, and the soil is a mere moss, unfit for agriculture. But the fur trade and fisheries, at its chief towns, Sidney and Louisbourg, are very considerable. The Bermudas, or Summer Islands, are situated about half-way between Nova Scotia and the West Indies.

Native Tribes, and Unconquered Countries.—These are, Greenland, Labrador, the regions round Hudson's and Baffin's Bays; the central parts, and the western coast. Greenland was visited by the Norwegians in the year 982, above 500 years before Colon discovered San-Salvador or Cat Island. But about 1406, about eighty-six years before Colon's discovery, by the gradual increase of the arctic ice, the Norwegian colony was completely imprisoned by the frozen ocean. This dreary region consists of rocks, ice, and snow; and in the south-west there are Danish and Moravian settlements. The botany is made up of junipers, willows, and dwarf birches. The zoology, of rein-deer, wolf-dogs, foxes, bears; sea-fowl, fish, and a few species of insects. The natives are American Samoieds, or Iskimois, short of stature, with long black hair, small eyes, and flat faces; and their numbers do not exceed ten thousand, chiefly employed in catching seals and in fishing.—Labrador, supposed to have been discovered by the Norwegians about the year 1003, receives its name from a Portuguese navigator, who, in 1500, arrived at it in search of a north-west passage. The natives are Iskimois savages of filthy manners, and a race of mountaineers resembling gipsies, but with French features, and in their religion Roman Catholics. This country abounds in bears, rein-deer, foxes, martins, and beavers; the lakes, rivers, and pools, are rich in salmon, trout, pike, barbel, and other fishes. The bears are remarkably fond of salmon, and will assemble in numbers at the cataracts where the salmon ascend, to catch their favourite prey. Some dive after the fish, and do not appear again till at the distance of sixty or seventy yards. But they are usually successful in the pursuit. Others appear mere loungers, that have come only to see the sport, and enjoy the promenade among the surrounding alders, spruce-firs, larches, birch, and aspin-trees. Nor is it an unusual thing for two score of white bears to be present at this spectacle!—The regions round Hudson's Bay are held by the Hudson's Bay Company, and the North-West Company, both English; hence these regions have been called New Britain. The parts on the west of Hudson's Bay have also been called New North and South Wales, while that on the east, between Labrador and the bay, is called East-Main. Hudson's sea presents bold rocky shores, or marshes, and large beaches; the winters, even in latitude 75°, are extremely severe; mock suns or halos are frequent; the sun itself rises and sets with a large cone of orange-coloured light; the aurora-borealis diffuses its variegated splendour with as much brightness as the full and cloudless silvery moon; and the stars scintillate with uncommon redness. The central parts are only known, from the travels of Hearne, Mackenzie, and Franklin. These parts are inhabited by various tribes of Indians, who are chiefly employed in hunting and fishing. The animals found are those peculiar to northern latitudes; the rivers and lakes are stored with fish and water fowl; and so numerous were the herds of elks and buffaloes which Mackenzie met with, where the scenery was interspersed with hill and lawn, that the country resembled a stall-yard. The natives towards the Pacific are fairer than those of the central parts, and evince a decided superiority in the arts and in their manners. The western coast comprises all those shores stretching from Behring's Strait to New Mexico. It is bounded inland by a great chain of mountains, and the whole region is chiefly alpine, bearing a strong resemblance to Norway. The natives are savages; in some tribes mild and affable, as well as just in their dealings; in others, cruel to strangers, and brutal to their captives taken in war, as the savages of Nootka and the Mosquinas, who massacred the Franciscan missionaries; and, among the whole, the females are held in abject subordination.

The Isles of Colon, or the West Indies.—These islands are Cuba, St. Domingo or Hayti, Jamaica, Porto Rico, the Antilles, Caribbee or Leeward islands, Trinidad, and the Bahama islands.—Cuba is 700 miles long, but only 70 broad. This island is fertile, producing excellent sugar, and the famous Havannah tobacco. It is governed by a Spanish governor-general and eighteen magistrates. The chief town is Havannah, and the people are fond of bull-fights, cock-fightings, balls, and good living.—St. Domingo, or Hayti, is now an independent empire; the national assembly of France having passed decrees for the mulattoes, or people of colour, to vote for representatives, the slaves rose against their oppressors, and after many battles, have effected their independence; and the island is now governed as a republic, after the fashion of the United States of America. The products of this island are similar to Cuba and Jamaica.—Jamaica, an English settlement, is 170 miles long, and 60 broad. It is divided into three counties, Cornwall in the west, Middlesex in the centre, and Surrey in the east. St. Jago or Spanish town, is the capital, and Kingston the chief sea-port. The products are sugar, rum, coffee, indigo, ginger, pimento. The legislature consists of a captain-general, or governor; a council of twelve, nominated by the king; a house of assembly, of forty members, who are freeholders. The bread-fruit tree has been introduced. The Blue Mountains rise 7430 feet above the level of the sea.—Porto Rico, belonging to Spain, is 120 miles long and 40 broad. It is a fertile, beautiful, and well-watered island; producing cotton, sugar, ginger, hides, drugs, and sweetmeats.—The Caribbee Islands, extending from Tobago in the south, to the Virgin Islands in the north, are of noted fertility and commercial advantage, producing sugar, cotton, rum, coffee, indigo, &c. These islands are, Barbadoes, Antigua, St. Christopher's, St. Vincent, Dominica, Grenada, Montserrat, Nevis, Trinidad, and the Virgin isles, belonging to Great Britain. The French Caribbee islands are Martinique, Guadaloupe, St. Lucie, Tobago, and some islets. The Danes possess St. Croix, St. Thomas, and St. John, attached locally to the Virgin group. St. Bartholomew belongs to Sweden; and St. Eustatius to the Dutch. Trinidad is about sixty miles long by fifty broad; the climate is delightful; and two-thirds of the soil is most fertile.—The Bahama or Lucayos Islands comprise Abaco, Bahama Eleuthera, Providence, Cat Island or San-Salvador, Crooked Island, and Cayo. The inhabitants are whites, English and Spanish, with many negroes. These West India islands afford cotton, logwood, mahogany, the cabbage-palm-tree, rising 200 feet, the tamarind tree, with its airy elegance and acid pods, the alder, and elm; the fruits are apples, peaches, figs, grapes, pomegranates, oranges, pine-apples, cashew-nuts, cocoa-nuts, and guavas; and the spices are numerous and exquisite.

South America.—The extent of this continent has already been noticed. It is divided into the Spanish dominions; the Portuguese dominions; the French dominions; the Dutch territories; and the countries possessed by the native tribes. The Spanish dominions once comprised the viceroyalties of La Plata, Peru, and New-Granada, with the Caraccas, and some inferior governments. The Portuguese dominions are, Brazil, and part of Guiana; the French and Dutch were also in Guiana; and the native tribes possess Patagonia and other countries. The Spanish dominions, that is to say, the countries subject to Spaniards, whether independent, or governed by the mother country, contain a population of 4½ millions of souls; and are divided into, 1*st*. The Territories on the Caribbean Sea, comprising Venezuela, Cumana, Guiana: chief towns, Leon de Caraccas, Cumana, St. Thomas. 2*dly*. The Territories on the Pacific, comprising New Granada, Peru, Chili, La Plata: chief towns, Carthagena, Lima, St. Jago, Buenos Ayres. Venezuela is now an independent republic; a portion of Cumana is also free from the Spanish yoke; and the whole of these territories have, in our own times, been erected into independent states. (1825.)

The Kingdom of La Plata.—The kingdom of La Plata, or Buenos Ayres, may be thus described. In extent it reaches from 14° south to near 38°, that is, 24°, or 1440 geographical miles in length; and in breadth about 12°, or 720 geographical miles. The population is about 2½ millions of souls. The government was managed by a viceroy, who had also the title of captain-general, and his jurisdiction extended to the whole of the political management, except the royal treasury; which was managed by the paymaster-general of the army. The strength of the army is not considerable, but some of its native troops are expert in the spear, the rope, and the ball. In their manners, the people resemble the European Spaniards, because it has been the policy of Spain to excite the colonists to remain in the new territories; and this she did by the superlative prudence of the council of the Indies, an assembly of her most enlightened men. Indeed, the whole government of the Spanish colonies in America, has, for a series of years, been managed by this council. The chief cities are, Buenos Ayres, on the west side of the river La Plata, an agreeable place, containing 40,000 inhabitants, and may be considered the grand mart of European goods passing to Peru. Montevideo is celebrated for its harbour; Santa Fé is on the great river La Plata; Potosi is famous for its mountain of silver, which the avarice and labours of 270 years have scarcely lessened. La Paz, an elegant and clean town in the same region, trades chiefly in the noted tea of Paraguay. Mendoza, in a pleasant situation on the eastern declivity of the Andes, is in the celebrated passage through those mountains to Peru. Chucuito, on the grand Lake Titicaca, is a cheerful and convenient town, surrounded by a cold climate, but a fertile soil. Pimo is a rich and populous town; Oruro is noted for its mines; Oropesa is the capital of Cochambamba, once the granary of Peru; Santa Cruz is a famous missionary station; Jujuy is celebrated for its cattle-



SOUTH AMERICA.

trade; Salta for its annual fair in the valley of Lerma, where 60,000 mules and 6000 horses are commonly collected for sale. The commerce between Buenos Ayres and Peru is carried on by means of little waggons drawn by oxen as far as Jujuy and Mendoza, where it is necessary to have recourse to mules on account of the mountain. Commerce having increased the circulation of money, agriculture has made rapid progress amidst the fertile plains of this extensive region. In regard to its natural geography, the kingdom of La Plata boasts of noble rivers, as the Parana or La Plata, the Paraguay, the Uruguay, and the Mendoza. The Mendoza has pierced a hill, and formed a natural bridge, over which three waggons may pass abreast. And its lakes are generally salt; but some are sweet water, and that of Titicaca is celebrated for an island in which the Incas dedicated a temple to the sun. The Indians have a tradition, that when the Spaniards entered the country, great treasures were thrown into this lake, and among others the great chain of gold, so long that 6000 men danced in the ring it formed. The mountains of Cordova, by some regarded as a branch of the Andes, are covered with perpetual snow. In the botany of La Plata, we find the cinchona, or Jesuits' bark, rhubarb, jalap; the carrob tree, which in winter affords a palatable drink and food to both man and beast; the tea of Paraguay, composed of the leaves of a small tree resembling the orange. In the zoology of this country, we find the American camel, or native sheep, from the wool of which a most elegant and durable cloth is manufactured; the American tiger or *jaguar*, and the *puma* or lion; the wild cat, the elk, the ant-bear, a kind of deer, hippopotami; the condor, an immense bird with a red crest, and black body spotted with white; the Paraguayan ostrich, partridges, serpents of prodigious size, &c. The mineralogy of this kingdom is extensive, and lucrative beyond all belief; for not to speak of Potosi, the mines of gold and silver are innumerable. In the province of Chaco, a mass of native iron, perfectly malleable, has been found. Near Jujuy is the hall of Eolus, a singular volcano, whence the winds rush out with overbearing whirls and clouds of dust. Not far from Cordova pent up winds issue out with violence by small apertures from the rocks, and produce a noise resembling the discharge of artillery at the siege of a fortress. And in the town itself, during a still night, the inhabitants hear passing, as it were from street to street, a dull murmur, like the noise produced by thumping with a wooden pestle in a huge mortar.

Kingdom of Peru.—Peru borders on New Granada on the north; on the north-east it joins the Pampa del Sacramento; on the east, the savage nations of the Pajonal; and on the south-east, the kingdom of Buenos Ayres. Its length has been computed 423 geographical leagues, and its breadth 80 leagues. The provinces are forty-two, but only a few have been described, though, among the native nations of America, the Peruvians are by far the most interesting. The number of towns and villages exceeds 1500. Like the other governments of Spanish South America, the viceroyalty of Peru consisted of two branches, political and ecclesiastical. The archbishop of Lima has four suffragans, and besides the chapters of these bishops, there are 557 curates of the royal presentation. In the Peruvian valleys between 5° and 15°, no rain falls, but vegetation is supported throughout this region by liberal dews. The high table-lands of the Andes, at the height of 10,000 feet above the level of the sea, enjoy a perpetual spring united with an eternal autumn; the fields are always verdant, the grains ever wave in golden harvests; and the fruit-trees are in blossom, in ripening, or in matured fruit. The chief cities are, Lima the capital, containing a population of 52,000 souls, and carrying on a great commerce with all parts of the world, by means of intermediate agencies: Cuzco, the second city, once the seat of the Peruvian monarchy, and having a population of 26,000 inhabitants. Lima is the maritime, Cuzco the inland, capital. The other cities are, Arequipa, Guamanga, Truxillo, Arica, Oropesa, Jauja, Lambayeque, Caxamarca, Ica, and Guanuco. Truxillo is subject to earthquakes; for unluckily the earthly paradise of the Andean table-land is in many places but an insidious soil, encrusting subterranean fires of sulphureous, alkaline, and aqueous matters, in perpetual fusion, to pour forth tremendous showers of destructive lava. The botany of Peru and Chili is extensive and various, for while the valleys on the sea-shore boast the common tropical plants, the milder plains on the Andean table-land are favourable to plants of a hardier constitution. The zoology of Peru differs little from that of La Plata; the mountain cat, a species of deer, foxes, bears, wolves; a sea-fowl with feathered body and membranous wings like the bats. The flamingo frequents the lakes. The silk-weaving spider, as large as a crab, and with teeth like a rat's, abounds in Jaen. In short, the whole country of Peru is one vast field of natural curiosities.

The Kingdom of New Granada.—New Granada extends from $3\frac{1}{2}°$ south latitude, to 12° north latitude, or $15\frac{1}{2}°$, being 930 geographical miles: and the medial breadth has been assumed at 240 geographical miles. The provinces are twenty-four in all, and the following is their natural geography:—The province of Jaen de Braenmoras, the most southern, producing gold, cotton, chocolate, and tobacco. The district of Cuenca, situated on the table-land of Quito, is of benign temperature, producing abundance of cattle, sugar, cotton, and grain. Macas, a considerable province on the eastern declivity of the Andes, has a warm and moist climate, and produces cotton, sugar, tobacco, and cinnamon. Riobamba, noted for the earthquake of 1797, when only 400 persons escaped out of 9000! Guayaquil is celebrated for its commerce. Terra Firma is a name given to Panama; and the province of Darien is extended on both sides of the gulf so called. Santa Fé enjoys a perpetual spring, and the abundance of nature may be presumed, from the fact, that here there are two harvests. San Juan de los Llanos consists of prodigious plains, of a fertile soil, and containing an abundance of cattle, with some gold mines. Antioquia is chiefly celebrated for its gold mines. Quito enjoys an uniform temperature; and the capital of the same name is famous as being the place where the French mathematicians measured a degree of the meridian. Popayan enjoys a perpetual spring, and abounds in fruits. The people of this province are noted for their integrity. Carthagena is noted for its European fashions, imported since its increasing commerce, wealth, and luxury. Santa Marta is famed as the province in which the Andes terminate. The chief rivers are the Magdalena and the Cauca. Some of the most useful vegetable productions have been already mentioned, as belonging to the other kingdoms; but there are plants peculiar to the Andes, whose genera, species, and nomenclature, belong not to this work. In the zoology, we find the tapir, an animal resembling a cow, but about the size of an ass; wild boars, deer, anteaters, the jaguar, the puma, wild cats, serpents, and alligators. In the mineralogy of New Granada, we find the rich gold mines of Choco and Antioquia; the silver mines of Marquetones; the emerald mines of Muzo; and the copper mines of Velez. Among the natural curiosities may be mentioned the vertical cataract of Bogota, precipitating its waters from a height of 300 fathoms. This cataract is the river Feunza, which, after passing along a narrow channel on a high table-land, is poured as from the spout of a vase in one arch of 1320 feet. The noise from the fall in the basin below, the spray, the clouds of vapour, the rainbows, the surrounding picturesque scenery of trees and shrubs, render the cataract of Tequendama one of the wonders of the world!

The Government of the Caraccas.—This government includes Venezuela, Maracaibo, Varinas, Cumana, (including Barcelona,) Spanish Guiana, and the Isle of Margarita. This government is now considered the republic of Venezuela, and therefore we shall notice the rather, its products, commerce, cities, and natural geography. Singular as it may appear, there are rivers in this district which rise on the sea-coast as it were, and flow inward. Beeves, horses, and mules, pasture in the interior; the vales alone are fertile. The cultivated articles are chocolate, indigo, and tobacco; but Hayti used to yield ten times the produce of the Caraccas. The great ports are Guayra and Porto Cavello, but the commerce is inconsiderable, and for a long time the greatest contraband trade was carried on. The chief towns are, Caraccas the capital, which, though enjoying a perpetual spring, was lately injured by an earthquake. Porto Cavello, an unhealthy place, and dangerous of access to the crews of foreign vessels. Valencia, a neat town; Maracay, a beautiful village, in the rich vale of Aragoa; Tulmero, in the same vale, a handsome town; Victoria, Coro, Cararo, Barquisimeto, Tocuyo, Guanana, Calabosa, Pao, San-Philippi, and Nirgua, are all places of minor importance. Cumana used to form a delegated government, consisting of the two provinces of Cumana and Barcelona. Cumana is subject to frequent earthquakes. Barcelona is noted chiefly for its breeding of swine; and the isle of Margarita as a military station, for the invasion of the Caraccas. The town of Maracaibo is rather unhealthy, and the thunder storms are terrible, but without them earthquakes prevail. The tobacco of Varinas is highly celebrated. The lakes are Maracaibo, famous for its mineral pitch, which at night serves, by its bituminous ignited vapours, as a lantern or pharos to the Spaniards and Indians; and the lake of Valencia, which, though receiving twenty rivers, discharges its superfluous waters by a subterraneous tunnel of evacuation, and nourishes amidst its swampy waters monstrous lizards, on which the natives feed. The rivers are, Orinoco, Aphuro, the Portuguesa, the Guarico, the Unari, and the Guarapicha. In the interior of Cumana there is a cavern called Guacharo, famous among the Indians for being of immense extent, and serving as a habitation for thousands of a kind of nocturnal birds, (or gnat-sucker,) which the Indians suppose to be the souls of their ancestors. This remarkable cavern is therefore visited with great ceremony.

Spanish Guiana.—Spanish Guiana is the province which, in some maps, the geographers call New Cumana, or New Andalusia. The territory of Guiana is bounded by the Orinoco, and the Negro rivers in the west and north; on the south by the Maranon; on the east by the Atlantic ocean. The part of Brazil on the north of the river Maranon, is called Portuguese Guiana. Spanish Guiana is bounded on the south-east by Dutch and French possessions; on the south, by the Portuguese; on the west, by the Rio Blancho, or rather the great river Negro; and the Orinoco on the south. Guiana is the seat of a bishop: the inhabitants sleep on the terraces of their houses during the great heats.

The Kingdom of Chili.—Chili is a delightful country, extending for more than 1260 geographical miles, along the great Pacific Ocean, flanked and protected by the vast belt of the Andes, which sends forth copious rivers to irrigate this envied soil. The breadth is about 210 miles. The northern boundary is the desert of Atacama; the Andes on the east divide Chili from Cayo, in the viceroyalty of La Plata; on the south it is bounded by barren mountains; and the Pacific Ocean washes its western shores. The grand belt of the Andes is here 120 miles broad, with transverse ridges full of ruptures and precipices; and eight or nine paths open to the Andes on the east, like those over the Alps in Switzerland, on shelves in the perpendicular rocks, hanging over profound precipices, so dangerous and difficult, that the steadiest mule ceases to be useful in those situations. The four seasons, in an inverted order, are as regular in Chili as in Europe. The fertility of the soil may be inferred from the fact, that a great part of it was in constant labour long before the Spaniards visited Chili, and to this day manure is unnecessary, for it yields, in general, from sixty to seventy-fold! and, what is singular, in a country wherein the soil, after a lapse of ages, and the avarice of man, has so little degenerated. Chili is the seat of the richest metallic ores; lead is found, of excellent quality; iron abounds, but it is neglected; the copper is perhaps superior to the British. The provinces of Santiago, Aconcagua, Coquimbo, and Copiapo, are celebrated for their silver mines; nor is there a mountain or hill which yields not gold, the purest in the world. With such a fertile soil, and enjoying so delightful a climate, the botany of Chili partakes of the plants of both hemispheres. Nettles, as in Europe, also our potherbs and fruits; and the sugar cane and sweet potato, and other tropical plants, flourish in the northern parts of this fine country. Our fine white strawberry, tipped with purple, and three inches in circumference, is derived from Chili, where it is cultivated as a crop; wild tobacco, sudorific and febrifuge plants; incense, equal to that of Arabia; balsam, excellent, both as an odour and a curative medicine. In the zoology, reptiles are rare; the seas abound in fish, the shores in lobsters and crabs, with oysters, seals, sea-cows, and innumerable aquatic fowls; and the hills in bees. The flamingo decorates the rivers, the humming bird the groves of flowers. The ostrich in Chili is equal to that of Africa; vultures and eagles, and condors, haunt the frightful precipices of the Andes. And amongst the quadrupeds we find dogs, hippopotami, foxes, lions of America; a singular wild horse, with cloven feet; and most of the European animals have improved in Chili. The most singular phenomenon, connected with the natural history of Chili, is the fact, that the ocean is retiring very rapidly on this coast, leaving curious grottos, hung with shells; and, in two instances, detached masses of white marble, scooped out like churches. The aboriginal Chilese are the Araneans and the Puelches. The former are the genuine representatives of the ancient Chilese; the latter, more rude and savage than the other natives, inhabit the mountains, and often change their abode, like the pastoral tribes of Asia. The Araneans have little beard; they are intrepid in war, hardy to endure fatigue, faithful to promises; but addicted to some of the savage vices. The Puelches are bold in war, faithful as allies, and may still be considered the unconquered Chilese. Such is the natural geography: the political is very brief.—Spanish Chili is divided into thirteen provinces, Copiapo, Coquimbo, Quillota, Aconcagua, Melipilla, Santiago, Rancagua, Colchagua, Manli, Itata, Chillau, Puciancy, and Huilquilema. They also possess Port Valdivia, in the country of the Cuchi, the Archipelago of Chili, and the island of Juan Fernandez. The entire government is managed by a captain-general; each of the provinces is ruled by a prefect, or corregidor. There are two vast bishoprics, Santiago and Conception, both suffragans of the Archbishop of Lima. The inquisition prevails at Santiago. The population is singularly mixed; wealth is wasted on dress, and equipages and titles of Castile; a countship being sold at so much, a marquisate at so much more, and the want of money alone prevents the whole people from being a nation of dukes. Chili is the original seat of vaccination; and among its medicinal herbs the vira-vira expels the ague; the payco assists indigestions: the culen supplies an excellent tea, known as a vermifuge; and the palqui is esteemed a superior febrifuge to Peruvian bark.

Brazil, and the Portuguese Possessions.—The Portuguese possessions extend from the frontier of Dutch Guiana, in latitude 3° north, to Port St. Pedro, in latitude 32° south. These 35° of latitude give us 2100 geographical miles for one dimension, and the other extent is even more, reckoning from Cape St. Roque to the settlement of St. Paul de Omaguas, on the river Amazons. The chief city of Brazil is San-Salvador, but Rio-Janeiro is more celebrated for its commerce; and the chief settlements are Para-Cano, on the estuary of the Maranon; Pernambuco, Sergippe, Paraiba, Villa-Grande, &c. But the whole territory of Brazil is now divided into eight independent governments, besides that of Rio-Janeiro; and the whole is now under the immediate eye of the Emperor, of the family of the king of Portugal. The population is estimated at 250,000 whites; 600,000 negroes; and 1,050,000 of natives. The climate in the south is delicious, and the soil fertile; but the north is exposed to rains, thunder, and storms. The valleys are rich, the forests extensive, and the rivers and mountains are both numerous and grand. The productions are, Brazil-wood, ebony, and dye-woods; esculent plants, common to the tropical climes; raisins, cotton, coffee, rice, pepper, and fruits. The European settlers are gay, and fond of pleasure; their domestics and labourers are slaves; and the indigenes are irreclaimable savages, muscular and active. Rio-Janeiro has a capacious and excellent harbour, protected by the castle of Santa-Cruz; yet both here, and in the other towns, the ceremonies of religion have degenerated into a vulgar worship of images. The mines of diamonds, in the province of Serro-de-Frio, and about latitude 17°, (and thus corresponding with the celebrated diamond mines of Visapour, in Hindostan,) are very much famed, though the brilliants they produce are much inferior to those of the East, being of a brownish obscure hue, and not of so fine a water. But diamonds are baubles in comparison of the valuable herds of wild cattle which range the forests of Brazil, and the medicinal plants of high estimation, that grow spontaneously, and in abundance.

The French Settlements in Guiana.—These settlements extend about 350 miles in length, by 240 in breadth; and the chief town is Cayano, whence the whole territory is called

Cayenne. The soil and climate are good, the Cayenne pepper is well known; and the other products are, sugar, cocoa, vanilla, and indigo.

The Dutch Possessions.—These are Dutch Guiana, called also Surinam, in length 350 miles along the coast of the Atlantic, by 160 in breadth inland. The chief towns are, Paramaribo, on the west bank of the Zealand river; and Demarara, on the river Esiquibo. It was this country that the unfortunate Raleigh attempted to penetrate, by the river Caroni, to the lake of Parima, whose sands were fabled of gold dust, and in the vicinity of which was the golden city of Manoa del Dorado. In the botany of Surinam we may notice its palms, of majestic height; the quassia; the castor-oil nut; ipecacuanha; caoutchouc, or Indian rubber: and poisonous trees and climbers abound. The entangled forests, and the swamps, are the sure retreats of panthers, serpents, and abominable reptiles.

Native Tribes and Unconquered Countries.—The internal nations are, the Abipons, a warlike tribe, and chiefly cavalry; the Mocobs; the Tobas; and the Aucas, in the same quarter. Towards the southern parts are the Puelches, or Patagonians; the Araucanos; the Telmels; and the Huilliches. The Abipons bury their dead under the shade of trees; and the horses of a chief are always sacrificed at his death. The Patagonians are the wandering, but humane Tartars of South America. And they bury their dead in a sitting posture, in square pits, with their weapons and cups beside them. These pits are annually opened by the matrons, and the bones of the skeletons dressed, those of the slain horses around being supported by props. Or they transport their dead to the sea-shore, where they deposit them in tents, with the skeletons of their horses placed around.

Islands belonging to South America.—These are the Galapagos; the isle of St. Felix; Juan Fernandez; the archipelagoes of Guaytecas and Toledo: in the former is the isle of Chiloe, 140 miles long, and 30 broad; in the latter is the isle of St. Martin, with some Spanish factories. Terra-del-Fuego, a dreary region, inhospitable and cold; and the isle of Statenland, is divided from Terra-del-Fuego by the straits of the Mairo. These countries, though in the reverse parallel of latitude (that is to say, in 55½° south latitude,) corresponding with Newcastle-upon-Tyne, in Northumberland, are yet more cold, and more severely frozen, than Lapland, in 70° of latitude North. The Falkland isles, (or Malouins, as the French call them,) boast of two, about 40 miles square, each; but the abundance of fowl and fish, caught here, ill make up the deficiencies felt from the poverty of the soil, and the perpetual storms which vitiate the climate. The isle of Georgia, to the south-east of the Falkland islands, though a land of ice, with vales destitute of trees and shrubs, and presenting only a coarse species of grass, is inhabited by the hardy lark.

Southern or Antarctic Continent.—This important discovery, which will be attended with incalculable advantages to our trade in the South Seas, was made in 1819 by a Mr. Smith, master of the William, of Blythe, in Northumberland. Our South Sea traders, who, during hostilities between this country and Spain, have been subjected to the greatest difficulties and privations, will now be independent of Spain, or any other power possessing South America. Mr. Smith ran for 2 or 300 miles along this continent, which formed large bays, abounding with the spermaceti whale, seals, &c. The drafts and soundings taken by the discoverer, are in the possession of our government. The following is the brief account which has been given of this discovery:—"A Mr. Smith, master of the William, of Blythe, in Northumberland, and trading between the Rio Plata and Chili, in endeavouring to facilitate his passage round Cape Horn, in 1819, ran to a higher latitude than is usual in such voyages, and in latitude 62. 30. and 60. west longitude, discovered land. As circumstances would not admit of a close examination, he deferred it until his return to Buenos Ayres, when he made such further observations as convinced him of the importance of his discovery. On making it known at Buenos Ayres, speculation was set on the alert; and the Americans at that place became very anxious to obtain every information necessary to their availing themselves of a discovery which they saw was pregnant with vast benefit to a commercial people. Captain Smith was, however, too much of an Englishman to assist their speculations, by affording them that knowledge of his secret which it was so necessary for them to possess, and was determined that his native country only should enjoy the honour and advantages of his discovery; and on his second voyage to Valparaiso, he devoted as much time to the development of it as was consistent with his primary object, a safe and successful voyage. He ran in a westward direction along the coasts, either of a continent or numerous islands, for 2 or 300 miles, forming large bays, and abound-with the spermaceti whale, seals, &c. He took numerous soundings and bearings, draughts and charts of the coast; and in short, did every thing that the most experienced navigator, despatched purposely for the object of making a survey, could do. He even landed, and, in the usual manner, took possession of the country for his sovereign, and named his acquisition New South Shetland. The climate was temperate, the coast mountainous, apparently uninhabited, but not destitute of vegetation, as firs and pines were observable in many places; in short, the country had, upon the whole, the appearance of the coast of Norway. After having satisfied himself with every particular that time and circumstances permitted him to examine, he bore away to the north, and pursued his voyage. On his arrival at Valparaiso, he communicated his discovery to Captain Sherriff, of his Majesty's ship Andromache, who happened to be there. Captain Sherriff immediately felt the importance of the communication, and lost not a moment in making every arrangement for following it up; he immediately despatched the William, with officers from the Andromache, and in this stage the last letter from Chili left the expedition, with the most sanguine expectation of success, and ultimate advantages resulting from it; and if we are correctly informed, a fully detailed narrative has been forwarded to government."—Captain Cook penetrated to a much higher latitude, and drew his conclusion from observing nothing but vast mountains of ice; yet his meridian was 45 degrees further to the west of New South Shetland, leaving a vast space unexplored on the parallel of 62, between that and Sandwich Land, in longitude 28 west. He again made 67, or thereabouts, but in longitude 137 to 147 west. Perouse ascended no higher than 60. 30; Vancouver about 55.—The Russian antarctic expedition, under Captain Bellinghausen, has, in 1819 to 1824, discovered two new islands within the antarctic circle. Both islands lie in about 69° south latitude; one of them, the isle of Alexander I. in 73° west longitude; the other, Peter Island, in 19° west longitude. Both were closely enveloped in ice, and no examination could be made of them.

AMETHYST, a transparent gem of a purple colour, found in the East and West Indies, and several parts of Europe. In Heraldry, the term signifies purple colour.

AMIANTHUS, in Mineralogy, earth flax, a fibrous, flexible, elastic, mineral, found in Germany; and by Kirwan classed along with the muriatic genus of earths, because it contains about one-third part of magnesia.

AMMI, Bishop's weed, the seeds of which are ranked among the four lesser hot seeds; but are scarcely otherwise made use of than as an ingredient in theriaca.

AMMODYTES, the sand eels.

AMMON, the Egyptian Jupiter, worshipped under the figure of a ram.

AMMONIA, a volatile alkali.

AMMONIAC, a vegetable, gummy, resinous juice.

Sal Ammoniac, muriate of ammonia, a native salt.

AMNIOS, a thin pellucid membrane that surrounds the fœtus in the womb.

AMOMUM, ginger, which is cultivated like potatoes, both in the East and West Indies. The uses of the root of this plant, both as a spice and medicine, are well known. In culinary matters, ginger is one of the best substitutes for eggs, as in making common suet dumplings, and puddings of all kinds.

AMORTIZATION, alienation of lands to a corporation and their successors.

AMPELITES, cannel coal, or candle coal. *See* Coal.

AMPHIBIOUS Animals, include all animals that live with equal facility on land or in water, and some others which do not exactly conform to this description. The amphibia, from the structure of their organs, and the power they possess of suspending respiration at pleasure, support uninjured a change of element, and endure a very long abstinence. The lungs differ in appearance from those of other animals. Numbers of amphibia possess a high degree of productive power, and will be furnished with new feet, tails, &c. when, by any accident, those parts have been destroyed. Their bodies are sometimes defended by a hard, horny shield or covering; sometimes by a coriaceous or leathery integument; sometimes by scales; sometimes they have no particular coating. The amphibia, in general, are tenacious of life, and continue to move and exert many of the animal functions, when deprived of the head itself. By far the greater part are *oviparous*, some excluding eggs, covered with a hard or calcareous shell, like those of birds; others, such as are covered only with a tough skin, resembling parchment; and in many, they are perfectly gelatinous, without any kind of external covering, as in the spawn of a frog. The amphibia are divided into Reptilia, containing the ampbibia pedata, or footed ampbibia; and the serpentes, or footless amphibia. In the Reptilia, there are four genera: 1. *Testudo*, tortoise, turtle. 2. *Rana*, frog, toad. 3. *Draco*, dragon, or flying lizard. 4. *Lacerta*, lizards, crocodile, chamæleon, newt, salamander, iguana. Reptiles are characterized by breathing through their mouths; and by having feet, and flat naked ears; of this order are frogs, lizards, and tortoises. Serpents are distinguished as being without feet, but frequently armed with a deadly poison, contained in fangs resembling teeth. In cold and temperate climates they conceal themselves in winter in cavities beneath the surface of the ground, where they become torpid. Some serpents are viviparous, as the rattlesnake, the viper, &c.; but those which are innoxious are oviparous, depositing their eggs in a kind of chain in a warm situation, where they are afterwards hatched. The broad laminæ on the bellies of serpents are termed scuta, and the smaller, or divided ones, beneath the tail, are called scales, and from these the genera are characterized.

AMPHICROSTYLES, a temple with four columns in front, and four in rear.

AMPHICTYONS, an assembly composed of deputies from the different states of Greece.

AMPHISCII, those who inhabit the torrid zone.

AMPHITHEATRE, an elliptical building, in which spectators assembled to witness spectacles of wild beasts, gladiators, &c. The nobility of Rome who courted popular favour, vied with one another in entertaining the people with these horrid amusements. Lucius Metellus, Pompey, Cæsar, Augustus, and Vespasian, with his son Titus, all erected amphitheatres. Herod of Judea erected amphitheatres both at Jerusalem and Cæsarea. During the reign of Tiberius, the amphitheatre of Fidenæ fell, and buried in its ruins about 50,000 persons.

AMPLIFICATION, the enlarging of a narration; and the soul of discourse with the ancients.

AMPLITUDE, an arc of the heavens intercepted between the east and west point, and the centre of the sun or of a planet, when rising or setting; and so is either north or south, ortive or occasive.

AMPUTATION, the cutting off a limb, &c. *See* Surgery.

AMULET, a charm, talisman, or preventive against mischief, witchcraft, and diseases; and usually made of such stuff as the imagination of impostors, and the credulity of simpletons, can devise: as, a stone, or a piece of metal; an animal; the letters of the alphabet, &c.

Amulet, *To make an.* Put a quarter of a pound of butter into a frying pan; break six eggs, beat them a little, and strain them through a hair sieve. Put them in when the butter is hot, and strew a little shred of parsley and boiled ham scraped fine, with nutmeg, pepper, and salt. Fry it brown on the under side: lay it on your dish, but do not turn it. Hold a hot salamander half a minute over it, to take off the raw look of the eggs: stick curled parsley in it, and serve it up. Some put in clary and chives, or onions. We have eaten Amulets made both ways; and a substantial dish they make, for a long journey.

Amulet *of Asparagus, To make an.* Take six eggs, beat them up with cream; boil some of the largest and finest asparagus. When boiled, cut off the green and small pieces, and mix them with the eggs, and some pepper and salt: make your pan hot, put in a slice of butter, then your eggs, &c. and send them up hot—on buttered toasts, if you please.

AMYGDALUS, sweet or bitter almonds. *See* Almonds.

AMYLACEOUS, a term applied to the fine flour of farinaceous seeds, in which consists their nutritive part.

ANACLASTIC Glasses, sonorous glasses, made chiefly in Germany. They resemble inverted funnels, whose bottoms are as thin as the peel of an onion; and upon applying the mouth to the orifice, and gently sucking out the air, the bottom gives way with a crash, and the convex becomes concave. Breathe into the orifice, and the vessel becomes gibbous as before.

ANACONDO, a large and terrible snake, found in Ceylon.

ANAGALLIS, pimpernel; to the leaves of which many extraordinary virtues have been attributed.

ANAGYRIS, bean trefoil.

ANALOGY, a certain relation or agreement between two or more things. In reasoning, analogy serves to explain or illustrate. Every physical resemblance may be reduced to two or more equalities; and every moral resemblance to two or more identities; and these are discernible only by intellect.

ANALYSIS, generally speaking, the resolution of something into its constituent parts; in Mathematics, the method of resolving problems by means of algebraic equations, which consider, in a single line, what in the ordinary process would occupy pages. Analysis is divided into *finite* and *infinite*, *determinate* and *indeterminate* and *residual*. Analysis of *powers*. Analysis of *curves*, &c. Hence,

ANALYST, one skilled in Algebra; and

ANALYTICS, the science or doctrine of analysis

ANAMORPHOSIS, in Perspective and Painting, a monstrous projection, or representation of some image, either on a plane or curve surface, deformed or distorted; but which, in a certain point of view, shall appear regular, and in just proportion.

ANASARCA, a species of dropsy.

ANASTATICA, the rose of Jericho.

ANASTROUS Signs, in Astronomy, a name given to the *duodecatemoria*, or the twelve portions of the ecliptic, which the signs anciently possessed, but which have since been deserted by the precession of the equinoxes.

ANATOMY, the dissection and study of the human body, which is a compound of solids and fluids. The solids are the bones, muscles, &c.; the fluids are the blood, secretions, &c. The bones are hard, white, insensible substances, full of spongy cells and reticular fibres. The bones of every skeleton are perfectly adapted to the extremity of those with which they are connected; and this connexion forms what is called Articulation. The cartilages are white, smooth, solid, but elastic substances, whose number in the adult subject is less than in children. The periosteum, a fine membrane of a cellular texture, covers the bones at their joints, and is supplied with nerves, lymphatic vessels, &c. The marrow, a fat oily substance filling the cavities of the bones, is supplied with numerous blood-vessels from the periosteum. The marrow seems to be to the bones what fat is to the muscles. The synovial glands lubricate the joints. The ligaments tie the bones together. The *bursæ mucosæ* are sacs capable of confining air or any other fluid; they are placed between the tendons and the bones, or beyond these, and sometimes at the extremities, and they are lubricated by a liquid resembling that which lubricates the joints. The *skeleton*, divided into the head, trunk, and limbs, is merely an assemblage of the bones of an animal, united in their natural order. The common integuments, with their appendages, are the cuticle or scarf-skin, which invests the body every where, and covers the true skin. The *rete mucosum*, is a mucous substance between the epidermis and cuticle, which gives colour to the body; for in negroes it is perfectly black, while the true skin is of the ordinary colour. The *cutis*, or true skin, is that from which leather may be made, and has throughout its whole surface innumerable papillæ, calculated to receive the impressions of touch. Thus the rete mucosum keeps the cuticle and cutis soft, and the cuticle protects both. Insensible perspiration, or that subtile vapour exhaled from the body by the glands of the skin, becomes, by union and condensation from the atmosphere, drops of sweat, which are analogous to urine in taste and nature. Accordingly, as either of these secretions is increased, the other is diminished. The nails cover and defend the exterior points of the fingers and toes, as hard transparent horns. The hair, growing from distinct bulbs in the skin, covers the head and different parts of the body. The cellular membrane and fat, are reservoirs of oily matter from the blood, that afford moisture to the parts with which they are connected. The muscles are the fleshy organs of motion; and are divisible into acute and insensible organs. The abdomen, or lower belly, contains the *peritoneum*, surrounding the viscera; the omentum is a cawl, or double membrane, interlarded with fat, and floating on the surface of the intestines; the stomach, a large bag lying across the upper part of the abdomen, which receives the aliment through the œsophagus cardia. The *œsophagus*, or gullet, resembles a funnel or canal, extending from the bottom of the mouth down to the diaphragm, or about the 11th or 12th vestebra of the back, where it terminates in the stomach. The intestines form a canal about six times the length of the body, extending from the inferior orifice of the stomach to the anus, being divided into two classes, the large and small. The mesentery is a part of the peritoneum, situated amid the intestines. The pancreas is a conglomerate gland situated behind the stomach, and serving by its liquor to dilute the alimentary pulp, and to incorporate it more easily with the bile. The liver, a glandular substance formed for the secretion of the bile, is placed in the right hypochondrium, under the false ribs.—There are various other parts of the abdomen, which, in a popular work, may be advantageously omitted. The thorax, or chest, contains the breasts, the pleura, thymics, diaphragm, trachea, the lungs, the functions of respiration, and of voice. And under this division, surgeons reckon digestion, or the voiding of the feces; the pericardium; the heart and its auricles; the blood-vessels; arteries; glands and secretions; the brain nerves; the senses and their organs, as touch, taste, smelling, hearing, vision, &c.

Comparative ANATOMY examines, 1st. The general variations in the organization and functions of animals. 2d. The general relations which take place among the variations of organization and functions. 3d. The arrangement of animals founded on the general difference of their organization, ascending from the simplest to the most perfect structure; 4th, the anatomy of mammalia, or quadrupeds; 5th, of birds; 6th, of reptiles; 7th, of fishes; 8th, of mollusca; 9th, crustacea; 10th, insects; 11th, worms; and 12th, zoophytes.

ANCHILOPS, a tumor near the inner angle of the eye.

ANCHOR, a crooked instrument of iron, dropped from a ship into the sea, to moor her to some particular station. In the diagram, fig. 65, *b* is a strong bar of iron, at the lower end of which are the two arms *d*, *e*, of equal thickness with the beam *b*, which is usually called the shank. The arms taper, and are fixed at an angle of 30 degrees; *g* and *h* are the flukes of the anchor, shaped like an isosceles Δ. The stock is a long beam of oak at *f*, consisting of two pieces strongly bolted together, as seen in fig. 66; in which is a massive ring, to which the cable is fastened. Every ship has three principal anchors, with a cable to each; *viz.* the sheet, best bower, and small bower anchors.

Fig. 65.

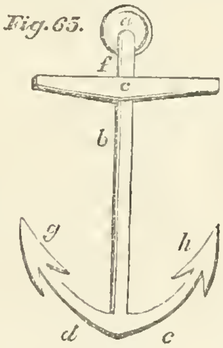
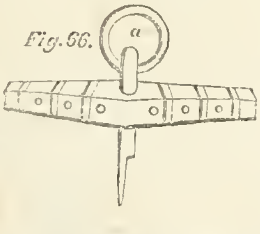


Fig. 66.



Method of making Anchors.—The goodness of an anchor is of great importance, and care is therefore taken, that the metal it is made of, be neither too soft nor too brittle, the latter rendering it liable to break; and the former to straighten. The shanks, arms, and flukes, are forged separately, then the hole is made at one end of the shank for the ring, which is put into the hole of the shank, and the two ends shut togeth After which, the arms are shut to the shank one after the other, and the anchor is finished. Proof is made of anchors, as of coats of mail anciently, by raising them to a great height, and then letting them fall again on a kind of iron block, placed across for the purpose. To try whether the flukes will turn to the bottom and take hold of the ground, they place the anchor on an even surface, with the end of one of the flukes, and one of the ends of the shank, resting on the surface: in case the anchor turns, and the point of the fluke rises upwards, the anchor is good. In England, France, and Holland, anchors are made of forged iron; but in Spain, and several parts of the South Sea, they are sometimes made of copper. For the proportions of anchors, the shank is thrice the length of one of the flukes, and half the length of the beam; or the length of the anchor is four-tenths of the greatest breadth of the ship. So that the shank of an anchor, in a vessel 30 feet wide, must be 12 feet long. When the shank is eight feet long, the two arms are seven feet long, measuring them according to their curvity. As to the degree of curvity given the arms, there is no rule in it; the workmen are here left to their own discretion. The anchor of a large heavy vessel is smaller in proportion than that of a lesser and lighter one: because the sea employs an equal force against a small vessel as against a great one. Supposing the extent of wood upon which the water acts, to be equal in both, yet the smaller vessel, by reason of its superior lightness, does not make so much resistance as the greater; the defect whereof must be supplied by the weight of the anchor. From hydrostatic principles, the following Table has been formed; wherein is shewn, by means of the ship's breadth within, the proportions in length of the other parts of the anchor. In this Table is represented likewise the weight an anchor ought to be for a ship from 8 to 45 feet broad, increasing by the breadth of one foot; supposing that all anchors are similar, or that their weights are as the cubes of the lengths of the shanks.

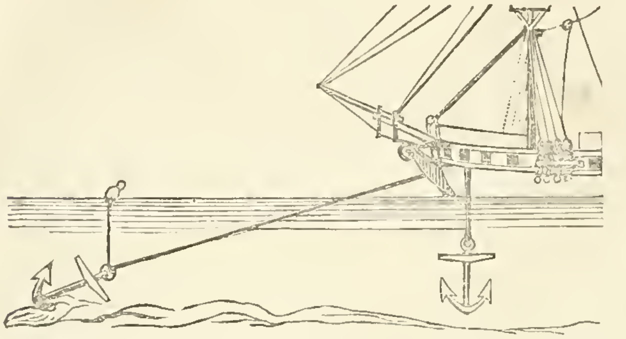
M. Bouguer directs to take the length of the shank in inches, and to divide the cube of it by 1160 for the weight, because the quotient of the cube of 201 inches, which is the length of an anchor weighing 7000 lb, divided by the weight, is 1160; and therefore, by the rule of three, this will be a common divisor for the cube of any length, and a single operation will suffice. The same author gives the dimensions of the several parts of an anchor, thus:—The two arms generally form the arch of a circle, whose centre is three-eighths of the shank from the vertex, or point where it is fixed to the shank; and each arm is equal to the same length, or the radius; so that the two arms together make an arch of 120 degrees: the flukes are half the length of the arms, and their breadth two-fifths of the said length. With respect to the thickness, the circumference at the throat or vertex of the shank, is generally made about a fifth part of its length, and the small end two-thirds of the throat; the small end of the arms of the flukes, three-fourths of the cir-

TABLE.

BREADTH OF THE VESSEL. Feet.	LENGTH OF THE ANCHOR. Feet.	WEIGHT. Pounds.
8	3⅕	33
9	3⅗	47
10	4	64
11	4⅖	84
12	4⅘	110
13	5⅕	140
14	5⅗	175
15	6	216
16	6⅖	262
17	6⅘	314
18	7⅕	373
19	7⅗	439
20	8	512
21	8⅖	592
22	8⅘	681
23	2⅕	778
24	9⅗	884
25	10	1000
26	10⅖	1124
27	10⅘	1259
28	11⅕	1405
29	11⅗	1562
30	12	1728
31	12⅖	1906
32	12⅘	2097
33	13⅕	2300
34	13⅗	2514
35	14	2742
36	14⅖	2986
37	14⅘	3242
38	15⅕	3512
39	15⅗	3796
40	16	4096
41	16⅖	4426
42	16⅘	4742
43	17⅕	5088
44	17⅗	5151
45	18	5832

cumference of the shank at the throat. This dimension should be greater when the iron is of a bad quality, especially if cast iron is used instead of forged iron.

At Anchor, the situation of a ship when she rides upon her anchors.——An Improved Anchor Launch or Boat, for large ships has recently been invented. In the middle of the boat a bottomless well-hole is constructed in the form of a cross, of suitable dimensions to admit the flukes of the anchor (when in an upright position) down one of the arms of the cross, and the stock of the anchor down the other. In order to send out and drop an anchor, it is lowered down into the well-crop of the boat from the bow of the ship, and, thus suspended to the boat, it is secured by lashing, so that it may be cut away and dropped at the instant it is required. Previous to lowering the anchor from the ship into the boat, the cable is slackened out, and drawn up through the well-hole; the anchor being then placed as before mentioned, the cable is fastened to the ring of it, in such manner as to be clear of the boat when the anchor falls. Several of these anchor launches are at present in use in the navy.



Anchor *Ground*, a bottom of sea neither too deep, too shallow, nor rocky. In Architecture, anchors are ornaments among the borillons of the Tuscan, Doric, and Ionic capitals. In Heraldry, emblems of hope, either spiritual or temporal.

ANCHUSA, yellow anchusa, or blue-flowered bugloss: the juice of its corolla, or flower, gives out to acids a beautiful green. An infusion of these flowers refresh the patient in hot, bilious, and inflammatory distempers.

ANCONES, the corners or quoins of walls, cross-beams, rafters, &c.

ANCYLOBLEPHARON, a disease of the eye, which closes the eyelids. If the cohesion is on the cornea, the sight is inevitably lost. If the eyelids adhere to the eye, they are to be separated by a fine knife, and their re-union prevented by injections, and lint placed between them, after dipping it in some proper liniment.

ANCYLOGLOSSUM, a contraction of the ligaments of the tongue: some have this imperfection from their birth; others from some disease. In the former case, the frænulum may stretch by the child's sucking, or it may be snipped by a pair of scissars, but not torn by the finger: the ulcers must be cured by surgical assistance.

ANCYLOSIS, a distortion or stiffness of the joints, caused by a settlement of the humours, or a distention of the nerves; and therefore remedies of a mollifying and relaxing nature are required.

ANDANTE, in Music, a movement moderately slow, between *largo* and *allegro*.

ANDRACHNE, bastard orpine.

ANDROGYNOUS, in Zoology, an appellation given to animals which have both the male and female sex in the same individual. In Botany, the term is applied to such plants as bear both male and female flowers on the same root.

ANDROIDES, in Mechanics, a figure constructed so as to imitate the actions of man, as the automaton chess-player. *See* Chess.

ANDROMEDA, in Astronomy, a constellation in the northern hemisphere, of which the chief is Almaac, a star of the second magnitude. The stars in this constellation are, in Ptolemy's catalogue, 23, in Tycho's 23, in Helvelius's 47, and in Mr. Flamsteed's not less than 66. Some of the stars or Andromeda have been reckoned among the changeable stars, whose brightness varies.

ANDROMEDA, in Botany, March cystus.

ANDROPOGON, in Botany, man's beard.

ANDRYALA, downy sowthistle.

ANEMONE, wild flower, which is gently astringent.

ANEMOMETER, in Mechanics, fig. 68, implies a machine for measuring the force and velocity of wind. Various machines of this kind have been invented at different times, and by different persons. The following has been often experienced, and found to answer the intentions. An open frame of wood, A B C D E F G H I, is supported by the shaft or arbor I. In the two cross pieces H K, L M, is moved an horizontal axis Q M, by means of the four sails, *a b*, *c m*, *o f*, *g h*, exposed to the wind in a proper manner. Upon this axis is fixed a cone of wood, M N O; upon which, as the sails move round, a weight, R or S, is raised by a string round its superficies, proceeding from the smaller to the larger end N O. Upon this larger end, or base of the cone, is fixed a rachet-wheel K, in whose teeth the click X falls, to prevent any retrograde from the depending weight. The structure of this machine sufficiently shews, that it may be accommodated to estimate the variable force of the wind; because the force of the weight will continually increase as the string advances on the conical surface, by acting at a greater distance from the axis of motion; consequently, if such a weight be added on the smaller post M, as will just keep the machine in equilibrio in the weakest wind, the weight to be raised, as the wind becomes stronger, will be increased in proportion, and the diameter of the cone N O may be so large in comparison to that of the smaller end at M, that the strongest shall but just raise the weight at the greater end. If, for example, the diameter of the axis be to that of the base of the cone N O, as 1 to 28; then if S be a weight of 1 pound at M on the axis, it will be equivalent to 28 pounds when raised to the greater end: if, therefore, when the wind is weakest, it supports one pound on the axis, it must be 28 times as strong, to raise the weight to the base of the cone. If, therefore, a line or scale of 28 equal parts, be drawn on the side of the cone, the strength of the wind will be indicated by that number on which the string rests.

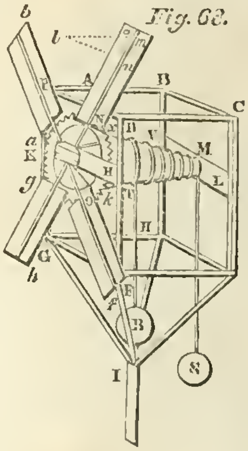


Fig. 68.

It is well known to philosophers, that rain, on the presence or absence of which at the different seasons of the year, vegetation, and the success of agriculture, in great measure depend, and also the temperature of the atmosphere, to whose influence both animals and vegetables are subject, arises from, or at least is strictly connected with, the various directions and velocities of winds. Nor has it escaped observation, that the primary cause of the direction of the wind from a given quarter, as well as of the velocity of its progress, is the rarefaction of the atmosphere in that tract towards which it blows. The reason why air does not rush in from all sides towards the rarefied tract, seems to me to be the inequality of its density in the surrounding tracts; for from that quarter, in which the mercury in the barometer stands highest, the air must preferably proceed. If the density be equal on all sides, as in some confined tracts, a hurricane happens: hence the advantage of ascertaining and comparing the degrees of its velocity; for, those being known, its cause, and degrees of rarefaction, may with great probability be inferred. Two causes of rarefaction are already known,—solar heat, and some internal chemical action, by which a quantity of air is converted into water, and sometimes even into a stony substance; this last being

Fi...

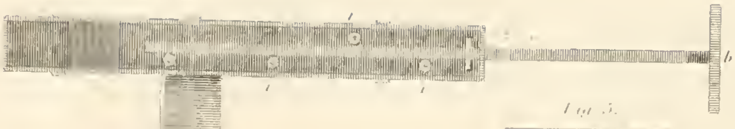


Fig. 5.

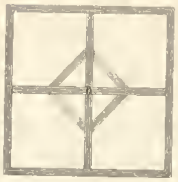


Fig. 6.

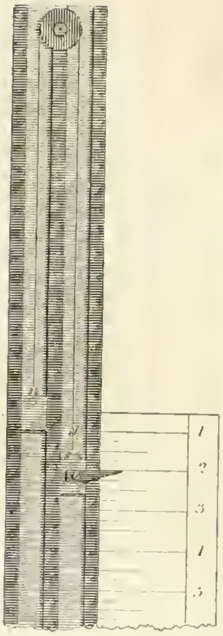
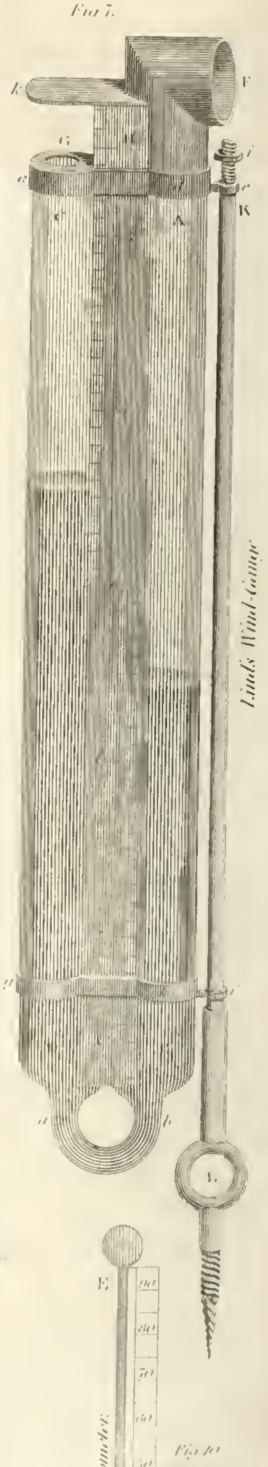


Fig. 7.



Lind's Wind-Gauge

Fig. 1.

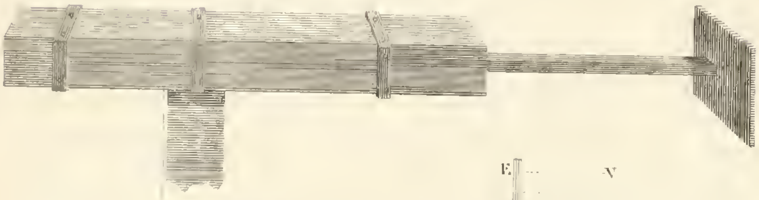
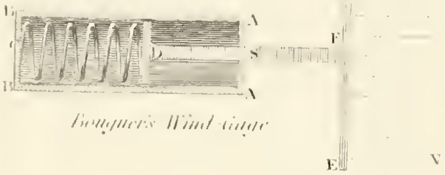


Fig. 9.



Bouguer's Wind-gage

Fig. 2.

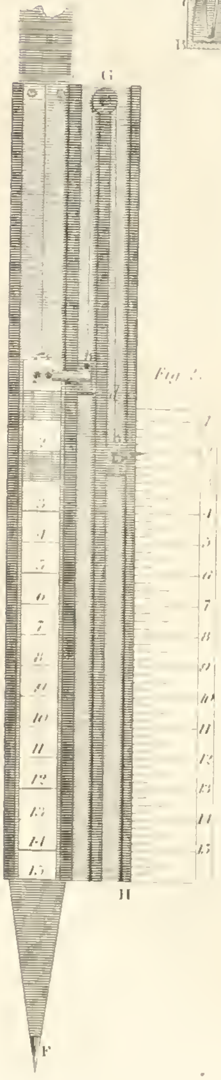


Fig. 8.

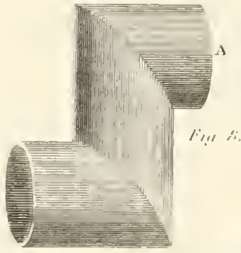
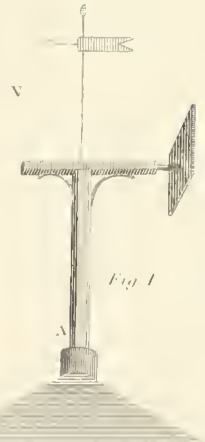
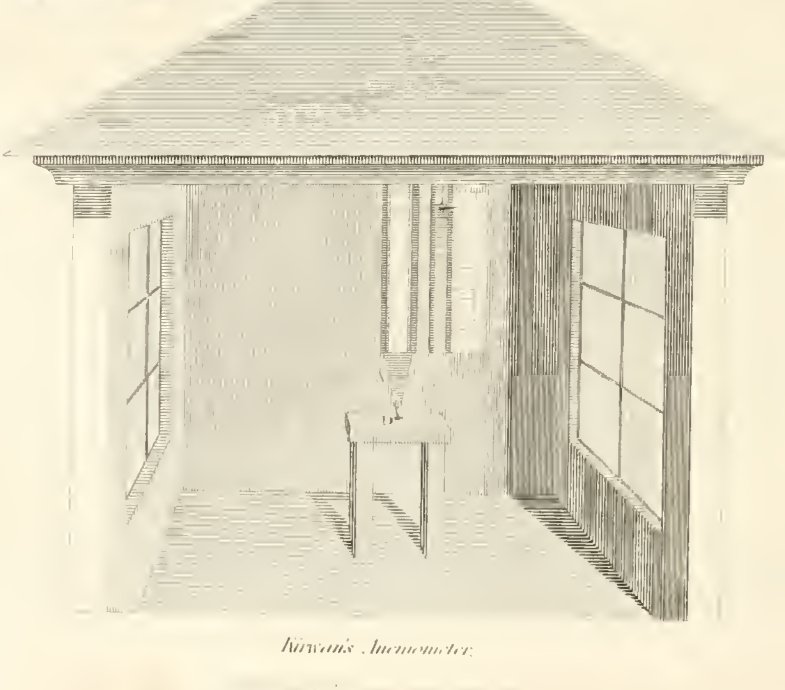


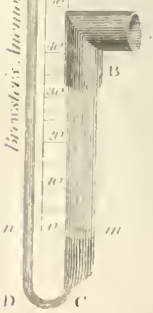
Fig. 4





Kirwan's Anemometer.

Fig. 10



Brewster's Anemometer.

the most sudden and complete, the rarefaction of the neighbouring air arising from it is by far the most violent, but commonly of a much shorter duration and more limited extent. An accurate measure of the velocity of wind has long been sought by meteorologists. The force of wind, to which the degrees of its velocity are proportional, is measured by that of gravity, indicated in pounds and parts of a pound avoirdupois; the calculation is grounded on the observations of Mr. Smeaton, who indeed observes, that the evidence of the velocity is not so great where this exceeds 50 miles, as when 50 or under; yet, from its agreement with other observations, I am inclined to think it fully sufficient. A velocity of 123 feet per second was observed at Petersburgh, in 1741, that is, at the rate of 83·8 miles per hour. According to Lalande, the course of the trade-winds is between 6 and 7 miles an hour. Mr. Brice, (Philosophical Transactions, 1756, p. 226,) observed a storm whose velocity was 63 miles per hour. A fair wind at sea, is that whose velocity amounts to 20 feet per second, or 16·63 miles per hour. Bouguer found the velocity of winter storms to be about 34 miles per hour, and in summer nearly 43. *Ibid.* The distance from Holyhead to the Pigeon-house, Dublin Bay, is 70 miles; then supposing the wind to be direct, and its velocity 30 miles per hour, and if we suppose the packet-boat to assume 0·4 of the velocity of the wind, it will arrive at the Pigeon-house in 5·8 hours. Let W denote the velocity of wind in the open air, or meeting no opposition; D = the distance of the place towards which the wind tends; N the number of hours it requires to traverse that distance; then any two of these being known, the other may be found by the following formulas.

Given.	Sought.	
W. D.	N.	$N = \frac{D}{W}$
W. N.	D.	$D = WN$
D. N.	W.	$W = \frac{D}{N}$

Thus if $W = 30$, $D = 70$
then $N = \frac{70}{30} = 2·33$
$D = 30 \times 2·33 = 70$
$W = \frac{70}{2·33} = 30.$

A well-sailing ship assumes $\frac{1}{3}$ the velocity of the wind. The best-sailing ship 0·4 of the wind's velocity.

The above Formulas applied to the Calculation of a Ship's Way.

Given.	Sought.	
0·4 W. D.	N.	$N = \frac{D}{0.4W}$
0·4 W. N.	D.	$D = 0·4\,WN.$
D. N.	0·4 W.	$0·4\,W = \frac{D}{N}$

Thus the wind 30, and the distance 70 miles, then the number of hours requisite to traverse that distance will be 5·1 for 30 × 0·4 = 12·0 and 12)70 = 5 8 hours. Again, 0·4 W being 12, and the hours, 5·8, being given, the distance 70 miles, we have 5·8 × 12 = 69·6, by the second formula. And lastly, the number of hours = 5·8, and space in miles = 70, being given, we have 0·4 of the velocity of the wind = $\frac{70}{5·8}$ = 12; and dividing this by 0·4, we have the rate per hour of its course in the lower atmosphere.

Dr. Kirwan's Anemometer. (See Plate, fig. 1.) The anemometer, with a vane or weather-cock placed on the top, to shew the direction of the lighter winds, which could not be known by the anemometer, on account of the weight of the necessary appendages annexed to it. This is raised of a sufficient height above the building, supported by a vertical axis or pole; the lower end of it passes through the roof and ceiling into an apartment below. Fig. 2. The lower part of the pole or vertical axis A A, fig. 1, more enlarged, to give a better view of the necessary appendages. The pole is made of a slender spar, such as are made use of for strong setting poles for lighters, and handles for boat-hooks, as not affected by lightning, which iron too often is, and the cause of the destruction of buildings and many lives. To this pole is fastened a frame of light wood by screws, in which the weights are confined, one on the top of another, in grooves, in such a manner as to work up and down with the greatest facility. The weights are connected together by cords, and marked 1, 2, 3, 4, &c.; the space between each, when drawn up by the force of the wind, is about one inch, as may be seen by the drawing, and each weighs one pound avoirdupois. To the top weight is fastened a line, and passing along the pole to the top, and over a brass pulley fixed at the bottom of the square tube, under the sliding rod B, fig. 3, as far as *a*, and there fastened: in this sliding rod a groove or channel is cut underneath, to receive the line, so as not to impede its passage over the brass rollers, *f, f.* The line is composed of a number of common sewing-threads, laid in different directions, well waxed, and enclosed in a cotton case, to prevent as much as possible its extension or contraction by the changes of the atmosphere. Fig. 3. The wooden pipe or tube, two inches square, fastened on the top of the pole A A, fig. 1, open on the side, to shew the manner that the sliding rod B passes over the brass rollers *f, f, f,* when the wind is sufficiently strong to lift up one pound by its force on the square surface presented to it, as *b* and *c*, fig. 4. Fig. 4. The wooden pipe or tube, in which are enclosed the sliding rod, rollers, and line, from the effects of the weather. Fig. 5. The wooden frame, made of light wood, one foot square, covered over with very thin sheet brass, strongly painted, and varnished with copal. This frame is fastened to the sliding rod B, fig. 3, by means of a mortise, &c. Fig. 6. An enlarged view of the scale and index, which marks the greatest force of the wind during the absence of the observer, which is attached to the frame confining the weights, as G H, fig. 2; and being connected with the hand fastened on the top weight (*d* fig. 2,) raises the small weight *e*; and this being counterpoised by another of equal weight, by means of a line passing over a small pulley, as represented by this figure, and also G, fig. 2, occasions the small weight, with its index, to stop at the number of pounds raised by the force of the wind, though they should fall down into their proper places on the wind's abating. The bottom of the vertical axis or pole F, fig. 2, is sheathed with a steel point, and a socket, which rest on a wooden stand or frame, as at D, fig. 1, so as to turn with ease, and avoid as much as possible any friction. In order to render this simple machine more complete, and answer the purpose of an anemoscope, as well as an anemometer, it is only necessary to apply to that part of the pole or axis, which is in the apartment, an index, and attach to the ceiling a thin deal board, or a sheet of pasteboard, with the points of the compass marked thereon.

A TABLE,

Shewing the Velocity of the Wind in Miles per Hour, indicated by Avoirdupois Pounds and Parts.

Miles per Hour.	Pounds and Parts.	Denominations.	Miles per Hour.	Pounds and Parts.	Denominations.	Miles per Hour.	Pounds and Parts.	Denominations.
10	0·492	Pleasant wind.	32	5·067	Storm.	53	13·923	——
11	0·615		33	5·386		54	14·464	——
12	0·738		34	5·705		55	15·007	——
13	0·861		35	6·025	Great storm.	56	15·548	——
14	0·981		36	6·394		57	16·089	——
15	1·107	Brisk gale.	37	6·763		58	16·630	——
16	1·279		38	7·132	Verygreat storm.	59	17·171	——
17	1·451		39	7·501		60	17·715	——
18	1·623		40	7·873		61	18·403	——
19	1·795		41	8·291	Violent tempest.	62	19·091	——
20	1·968		42	8·709		63	19·779	——
21	2·169	Very brisk gale.	43	9·127	Hurricane.	64	20·467	——
22	2·370		44	9·545		65	21·158	——
23	2·571		45	9·963		66	21·846	——
24	2·772		46	10·430		67	22·534	——
25	2·975		47	10·897		68	23·222	——
26	3·265	High wind.	48	11·364		69	23·910	——
27	3·555		49	11·831		70	24·602	——
28	3·845		50	12·300				
29	4·135	Very high wind.	51	12·841				
30	4·429		52	13·382				
31	4·748							

Dr. Lind's Wind-gage.—This instrument consists of two glass tubes A B, C D, (See Plate, fig. 7.) of five or six inches in length. Their bores are about four-tenths of an inch in diameter. They are connected together like a siphon by a small bent glass tube *a b*, the bore of which is about one-tenth of an inch in diameter. On the upper end of the leg A B there is a tube of latten brass, which is kneed, or bent perpendicularly outwards, and has its mouth open towards F. On the other leg C D, is a cover with a round hole G in the upper part of it, two-tenths of an inch in diameter. This cover and the kneed tube are connected together by a slip of brass *e d*, which not only gives strength to the whole instrument, but also serves to hold the scale H I. The kneed tube and cover are fixed on with hard cement or sealing wax. To the same tube is soldered a piece of brass, *e*, with a round hole in it to receive the steel spindle K L; and at *f* there is just such another piece of brass soldered to the brass hoop *g h*, which surrounds both legs of the instrument. There is a small shoulder on the spindle at *f;* upon which the instrument rests, and a small nut at *i*, to prevent it from being blown off the spindle by the wind. The whole instrument is easily turned round upon the spindle by the wind, so as always to present the mouth of the kneed tube towards it. The end of the spindle has a screw on it; by which it may be screwed into the top of a post, or a stand made on purpose. It has also a hole at L, to admit a small lever for screwing it into wood with more readiness and facility. A thin plate of brass, *k*, is soldered to the kneed tube, about half an inch above the ground-hole G, so as to prevent rain from falling into it. There is likewise a crooked tube A B, (fig. 8,) to be put occasionally upon the mouth of the kneed tube F, in order to prevent rain from being blown into the mouth of the wind-gage when it is left out all night, or exposed in the time of rain. The force or momentum of the wind may be ascertained by the assistance of this instrument, by filling the tubes half full of water, and pushing the scale a little up or down, till the zero of the scale, when the instrument is held up perpendicularly, be on a line with the surface of the water in both legs of the wind-gage. The instrument being thus adjusted, hold it up perpendicularly, and, turning the mouth of the kneed tube towards the wind, observe how much the water is depressed by it in the one leg, and raised in the other. The sum of the two is the height of a column of water which the wind is capable of sustaining at that time, and every body that is opposed to that wind will be pressed upon by a force equal to the weight of a column of water, having its base equal to the altitude of a column of water sustained by the wind in the wind-gage. Hence, the force of the wind upon any body where the surface opposed to it is known, may be easily found; and a ready comparison may be made betwixt the strength of one gale of wind and that of another. The force of the wind may be likewise measured with this instrument, by filling it until the water runs out at the hole G. For if it be then held up to the wind as before, a quantity of water will be blown out; and if both legs of the instrument are of the same bore, the height of the column sustained will be equal to double the column of water in either leg, or the sum of what is wanting in both legs. The use of the small tube of communication *a b*, (fig. 8.) is to check the undulation of the water, so that the height of it may be read off from the scale with ease and certainty. But it is particularly designed to prevent the water from being thrown up to a much greater or less altitude, than the true height of the column which the wind is able at that time to sustain, from receiving a sudden impulse whilst it is vibrating either in its ascent or descent. As, in some cases, the water in this instrument might be liable to freeze, and thus break the tubes, a saturated solution of sea-salt may be used instead of it in winter. Dr. Lind gives the following table, by means of which, from the observed height of the column of water in the gage, the force of the wind on a square foot may be determined.

For heights not given in the following table, proportional parts are taken and added: for example, if the height be 5·5,—then to 26·010, the force for 5 inches, add 2·601 the force for 0·5, the decimal part, and the sum of the two, namely, 28·615 pounds, is the answer. When a saturated solution of salt is used, allowance must be made for the difference in the weight of the fluid. The specific gravity of the solution being to that of water as 1·241 to 1, the observed height of the column must be multiplied by 1·241.

Height of the Water in the Gage.	Force of the Wind on One Foot Square in Pounds Avoird.	Common Designations of such Winds.
12 *Inches*	62·500	
11	57·293	
10	52·083	Most violent hurricane
9	46·875	
8	41·667	Very great hurricane.
7	36·548	Great hurricane.
6	31·750	Hurricane.
5	26·041	Very great storm.
4	20·833	Great storm.
3	15·625	Storm.
2	10·416	Very high wind.
1	5·208	High wind.
0·5	2·604	Brisk gale.
0·1	0·521	Fresh breeze.
0·05	0·260	Pleasant wind.
0·025	0·030	A gentle wind.

M. Bouguer's Wind-gage.—The instrument contrived by M. Bouguer consists of a hollow tube A A, B B, (fig. 9,) in which a spiral spring C D is fixed, that may be more or less compressed by a rod F S D passing through a hole within the tube at A A; then having observed to what degree different forces or given weights are capable of compressing the spiral, mark divisions on the rod in such a manner, that the mark at S may indicate the weight requisite to force the spring into the situation C D; afterwards join at right angles to this rod at F, a plane surface E F E of a given area, either greater or less, at pleasure; then let this instrument be opposed to the wind, so that it may strike the surface in the directions V E, V E, parallel to that of the rod, and the mark at S will shew the weight to which the force of the wind is equivalent.

Dr. Brewster's Anemometer.—Dr. Brewster has suggested various contrivances for measuring the force of the wind. Among these we think the following, which indicates the force by its effect in compressing a column of air in a glass tube, is the most commodious and accurate. The metal cap A B, (fig. 10,) bent at a right angle, is fixed upon the top of the glass tube B C, which communicates at C with another glass tube, D E, of a much smaller bore, with a bulb, E, at its end. Some mercury or other liquid is poured into the tube B C, and of course rises to the same level, *m*, *n*, in both tubes. When the mouth A is exposed to the wind, the liquid at *m* descends in the tube, and by rising in the stem D E, compresses the enclosed air till there is an equilibrium between the elasticity of the air and the force of the wind. To prevent the fluid from oscillating, a thin disk of wood floats on its surface at *m*. The scale of this instrument, to ensure accuracy, should be formed by actual experiment.

Professor Leslie's Anemometer.—It would be improper to close this article without noticing the ingenious suggestion of this philosopher, for measuring the force of the wind by its cooling power. Having found, in the course of his experiments on heat, that the cooling power of a current of air is exactly proportional to its velocity, he derived from this principle the construction of a new anemometer, which will be understood without any figure, being, to use his own words, "in reality nothing more than a thermometer, only with its bulb larger than usual. Holding it in the open still air, the temperature is marked: it is then warmed by the application of the hand, and the time is noted which it takes to sink back to the middle point. This I shall term the fundamental measure of cooling. The same observation is made on exposing the bulb to the impression of the wind, and I shall call the time required for the bisection of the interval of temperatures, the occasional measure of cooling. After these preliminaries, we have the following easy rule: Divide the fundamental by the occasional measure of cooling, and the excess of the quotient above unit, being multiplied by 4½, will express the velocity of the wind in miles per hour. The bulb of the thermometer ought to be more than half an inch in diameter, and may, for the sake of portability, be filled with alcohol, tinged, as usual, with archil. To simplify the observation, a sliding scale of equal parts may be applied to the tube. When the bulb has acquired the due temperature, the zero of the slide is set opposite to the limit of the coloured liquor in the stem; and after having been heated, it again stands at 20° in its descent, the time which it thence takes until it sinks to 10° is measured by a stop-watch. Extemporaneous calculation may be avoided, by having a table engraved upon the scale, for the series of occasional intervals of cooling."

[Other devices have been adopted by philosophical ingenuity, all of which we cannot even enumerate. Mr. Brice describes one, which has been successfully practised by himself, of measuring the velocity of the wind by means of that of the shadow of clouds passing over the surface of the earth.—Mr. Ons-en-Bray invented another, which of itself expresses on paper, not only the several winds that have blown during the space of twenty-four hours, and at what hour each began and ended, but also the different strength and velocities of each.]

ANEMOSCOPE, fig. 69, a machine that shews either the course or velocity of the wind. The machine which shews the course of the wind, or from what point of the compass it blows, consists of an index moving about an upright circular plate, like the dial of a clock, on which the 32 points of the compass are drawn instead of the hours. The index which points to the divisions on the dial, is turned by a horizontal axis, having a trundle-head at its external extremity. This trundle-head is moved by a cog-wheel on a perpendicular axis; on the top of which a vane is fixed, that moves with the course of the wind, and puts the whole machine in motion. The whole contrivance is extremely simple, and nothing required in the construction, but that the number of cogs in the wheel, and rounds in the trundle-head, be equal; because it is necessary, that when the vane moves entirely round, the index of the dial also make a complete revolution. An anemoscope of this kind is placed in one of the turrets of the queen's palace. The anemoscope, calculated for indicating the force, or the velocity of the wind, is the same with what most writers call an anemometer; and we have, accordingly, described several of those machines under that article. We shall here add another, constructed by the late Mr. Pickering, and published in the Philosophical Transactions, No. 473. This anemoscope, 4¼ feet high, consists of a broad and weighty pedestal, a pillar fastened into it, and an iron axis of about ½ an inch diameter, fastened into a pillar. Upon this axis turns a wooden tube; at the top of which is placed a vane, of the same materials, 21 inches long, consisting of a quadrant, quadrated and shod with an iron rim, notched to each degree; and a counterpoise of wood, as in the figure, on the other. Through the centre of the quadrant runs an iron pin, up which are fastened two small round pieces of wood, which serve as moveable radii, to describe the degrees upon the quadrant, and as handles to a velum or sail, whose vane is one foot square, made of canvass, stretched upon four battens, and painted. On the upper batten, next to the shod rim of the quadrant, is a small spring, which catches at every notch corresponding to each degree, as the wind shall, by pressing the sail, raise it up, and prevents the falling back of the sail, upon lessening the force of the wind. At the bottom of the wooden tube is an iron index, which moves round a circular piece of wood fastened to the top of the pillar on the pedestal, on which are described the 32 points of the compass. In fig. 69, this machine is shewn, where *a* is the pedestal; *b* the pillar on which the iron axis is fitted; *c* the circle of wood, on which are described the 32 points of the compass; *e* the wooden tube upon its axis; *f* the velum or sail; *g* the graduated quadrant; *h* the counterpoise of the vane. The adjoining figure, 70, *a* represents the velum; *b* the spring; *c c* the wooden radii; *d d* the holes through which the pin in the centre of the quadrant goes. Its uses are the following:—1. Having a circular motion round the iron axis, and being furnished with a vane at the top and index at the bottom, when once you have fixed the artificial cardinal points, described on the round piece of wood on the pillar, to the same quarters of the heavens, it gives a faithful account of that quarter from which the wind blows. 2. By having a velum or sail elevated by the wind along the arch of the quadrant to a height proportionable to the power of the column of wind pressing against it, the relative force of the wind, and the comparative power, at any two times of examination, may be accurately taken. 3. By having a spring fitted to the notches of the iron with which the quadrant is shod, the velum is prevented from returning back upon the fall of the wind; and the machine gives the force to the highest blast, since the last time of examination, without the trouble of watching it. The ingenious contriver of this machine tells us, that he carefully examined what dependence may be had upon it, during the storms of February 1743-4, and found that it answered exceedingly well; for that, in such winds as the sailors call violent storms, the machine had six degrees to spare for a more violent gust, before it comes to a horizontal position. It is certainly to be depended upon in ordinary weather, the velum being hung so tenderly, as to feel the most gentle breeze. There is, however, reason to fear, that the exposing of the anemoscope to all winds for a continuance, must disorder it; especially irregular blasts and squalls. It may not, therefore, be amiss, in violent squalls, for the observer to take the tube, with its vane and velum in his hand, in order to know the force of the wind; and when he has finished his observations, to carry his machine into the house, till the violence of the storm is abated, when it may be replaced in its former situation.

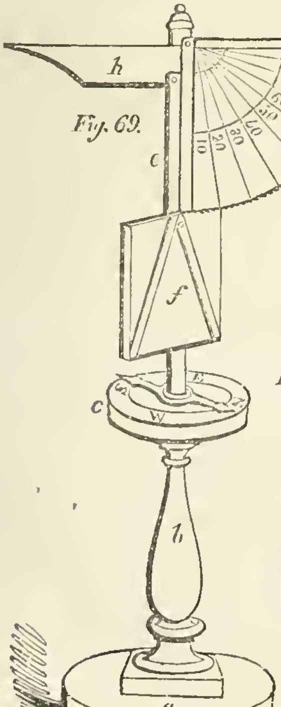


Fig. 69.

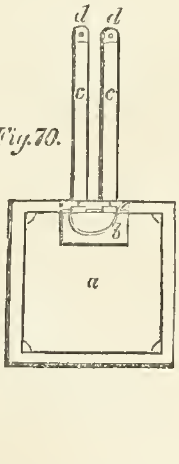


Fig. 70.

ANETHUM, dill and fennel.

ANEURISM, a throbbing tumor distended with blood, and formed by the dilation or rupture of an artery.

ANGEIOTOMY, the opening a vein or artery.

ANGELICA, *To Candy*. Angelica is cultivated only for the large ribs of its leaves, which are cut in May or June, and made into a candy as a medicinal plant. Take it when young, cut it in lengths, cover it close, and boil it till it is tender; peel it, and put it in again, let it simmer, and boil till it is green; then take it up, and dry it with a cloth. To every pound of stalks put a pound of sugar: put your stalks into an earthen pan. Beat the sugar, and strew it over them. Let it stand two days; then boil it till it is clear and green: put it in a cullender to drain. Beat a pound of sugar to powder again, and strew it on your angelica. Lay it on plates to dry, and set the plates in the oven after the pies are drawn. 3½ lbs of sugar is the proportion to 4 lbs of stalks.

ANGINA, an inflammation of the throat, called the quinsy.

ANGLE, *Angulus*, in Geometry, is formed by the opening or mutual inclination of two lines meeting in a point; such is the angle B A C, or B A D.—*Note.* When an angle is denoted by three letters, that at the angular point must be read in the middle. But sometimes, for brevity sake, if there be but one angle at a point, that angle is denoted by the single letter standing at that point.

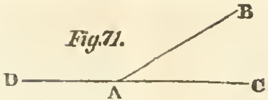


Fig. 71.

Angles are of several different kinds or denominations, as *rectilinear, curvilinear, spherical, mixed, solid,* &c. *Rectilinear* Angle, is that which is formed by the meeting of two right lines. *Curvilinear* Angle is that which is formed by the meeting of two curve lines. *Mixtilinear* Angle, is formed by the meeting of a right line and curve. *Spherical* Angle, is that which is formed on the surface of a sphere, by the intersection of two great circles. *See* Sphere and Spherical *Trigonometry. Solid* Angle, is formed by the mutual inclination of more than two planes, or plane angles, meeting in a common point. *See Solid* Angle.

Properties and Denominations of Rectilinear Angles.—Right Angle is that which is formed by one line perpendicular to another; or that which is subtended by a quadrant of a circle; as the angle B A C. All right angles are equal to one another. *An Oblique* Angle is that which is greater or less than a right angle; and these are distinguished into two kinds, *acute* and *obtuse. An Acute* Angle is less than a right angle, as D A C. *An Obtuse* Angle is greater than a right angle; as E A C. *Adjacent* Angles, are the two angles formed by one line meeting another, any where, except at its extremities; such are the two angles B A D and B A C. These angles are said to be supplements to each other, their sum being equal to two right angles. *Vertical,* or *Opposite* Angles, are such as have their legs mutual continuations of each other; as B A C and D A C. Vertical, or opposite angles, are equal to each other.

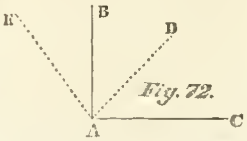


Fig. 72.

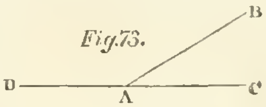


Fig. 73.

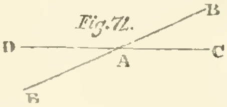


Fig. 74.

Alternate Angles, are those made on the opposite sides of a line cutting two other lines; as A F G and D G F. And if these two lines are parallel, the alternate angles are equal. *External* Angles, are those formed by the sides of any right-lined figure, and the adjacent sides produced; such are the angles A, B, C, &c. The sum of all the external angles of any figure is equal to four right angles. *Internal* Angles, are the angles within a figure, formed by the meeting of each two adjacent sides; as the angles *a, b, c,* &c. The sum of all the inward angles of any right-lined figure, is equal to twice as many right angles, wanting four, as the figure has sides. *An* Angle *at the Centre of a Circle,* is that whose angular point is at the centre; such as the angle A C B. *An* Angle *at the Circumference,* is that whose angular point is in any part of the circumference; as the angle A D B. An angle of the centre is double an angle at the circumference, when both stand on the same arc. *An* Angle *in a Semicircle* is an angle at the circumference contained in a semicircle, or standing upon a semicircle or diameter; and it is a right angle. An angle in a segment greater than a semicircle, is less than a right angle. An angle in a segment, less than a semicircle, is greater than a right angle. Angles of other denominations are used by some authors, as, the *Horned* Angle, formed by the circumference of a circle and a right line; *Lunular* Angle, formed by two curve lines, one concave and the other convex; and *Cissoid* Angle, the inward angle, formed by the intersection of the two spherical convex lines.

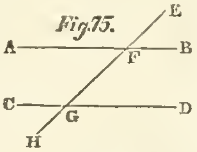


Fig. 75.

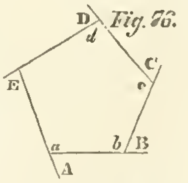


Fig. 76.

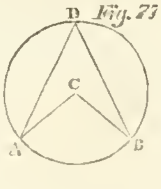


Fig. 77

Problems.—1. *To bisect a given Angle,* B A C. From the centre A, with any radius, describe an arc cutting off the equal lines A D, A E; and from the two centres D E, with the same radius, describe arcs intersecting in F, then draw A F; which will bisect the angle as required.

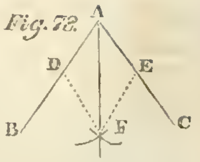


Fig. 78.

2. *At a given point* A *in the line* A B, *to make an Angle equal to a given Angle* C. From the centres A and C, with any one radius, describe the arcs D E, B G; then with the centre B, and radius D E, describe an arc cutting B G in G. Through G draw the line A G, and it will form the angle required.

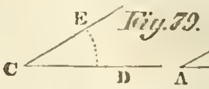


Fig. 79.

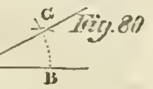


Fig. 80

3. *To Measure the Quantity of an Angle on Paper.*—Apply the centre of a protracter to the vertex of the angle, so that the radius may coincide with one of the lines; and the degree shewn by the other line, will give the measure of the angle required.

Otherwise with the Line of Chords.—With a radius equal to the chord of 60°, describe an arc between the lines forming the angle; then apply the subtense of this arc to the same scale of chords, and it will give the measure sought.

Angles, in Astronomy, receive the following particular denomination: as Angle of *Commutation,* of *Elongation,* of *Position,* &c.; for which, see the respective terms.

Angles, in Mechanics and Optics, also receive particular denominations, and are distinguished into separate orders; as Angles of *Direction, Elevation, Inclination, Inflection, Incidence, Refraction,* &c.; for which, see the respective terms. *Optic* Angle, is the angle included between two rays, drawn from the two extreme points of an object to the centre of the pupil of the eye.

ANGLING, among sportsmen, is the art of fishing, either with bait or flies, and a rod and line. The great secret of angling with bait is, to attract the fish to some particular spot by throwing in grains, chopped worms, &c. if the water is still; or if running, by enclosing a large quantity of worms in a tin box full of holes, by which the worms may crawl out and attract the fish. The anglers stand, sheltered by some bush or tree, as particularly at deep-water gullies, sluices, mill-dams, or ponds where the cattle go to water. Chub love deep shaded holes; eels are found under the banks of rivers and ponds; perch, in clear water and a swift stream; so are roach and trout found in quick currents; breams in deep quiet places. The best season for angling, is from April to October. A cloudy day, after a bright moonlight night, is good for fishing. Cool weather in summer, and warm weather in winter, are the fit seasons, from three till nine in the morning, and from three till sun-set in the afternoon. A southerly wind, in a dull warm day, is the best time of any

ANGOLA Pea, pigeon pea.

ANGOR, a concentration of natural heat; the consequence of which is, a pain of the head, palpitation, and sadness.

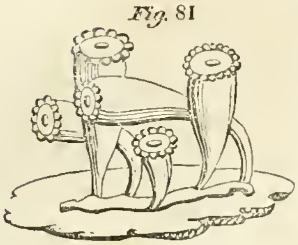
ANGUINEAL Hyperbola. *See* Hyperbola.

ANGULAR, something relating to, or having angles. Angular objects at a distance appear round.

Angular *Motion,* is that which is performed by an oscillating or vibrating body, as referred to the angle which it describes or passes over in a given time, the vertex of which is the point of suspension, or centre of motion. Hence all points in a pendulum have the same angular motion, although their absolute motions are different from each other, being greater or less, according to their distance from the centre of suspension. Angular *Motion* is also sometimes used to denote a motion which is partly curvilinear, and partly rectilinear; as the motion of a coach-wheel on a plane. Angular *Sections,* a term used by Vieta to denote a species of analytical trigonometry, relating to the law of increase and decrease of the sines and chords of multiple arcs.

ANIMAL, in Natural History, an organized and living body, endowed with sensation. Minerals increase; plants grow and live; but animals have the power of locomotion, of seeking and appropriating nourishment.

Fig. 81



Animal *Flowers*, or Sea Nettle, or Sea Anemone, fig. 81, is a fleshy substance, endowed with claws, stomach, mouth, &c. and found adhering to rocks in the sea by one end, and with the other voraciously devouring whatever food comes in their way.

Animal *Substances*, in Chemistry. The constituent principles of animal substances are nearly the same with those of the vegetables; the former, however, contain more of nitrogen and phosphorus; the latter, more of carbon and hydrogen. The complex constituent parts of animal substances are the following: — 1. Gelatine. 2. Fibrin. 3. Albumen. 4. Animal oils. 5. Bone. 6. Blood. 7. Milk. 8. Horn. 9. Phosphorus and animal acids.—Gelatine, or animal jelly, very generally dispersed through all the parts of animals, even in bones, exists in the greatest quantity in the tendons, membranes, and the skin.—Fibrin, or animal fibre, forming the basis of the muscular or fleshy parts of animals, is fibrous in its structure, transparent, and insoluble in water and alcohol, except by a long continued heat in a Papin's digester.—Albumen is the principal constituent part of the serum of blood; it is also called coagulable lymph. The white of eggs consists almost entirely of albumen.—Animal oil, generally solid at the temperature of the atmosphere, contains more oxygen and sebacic acid, than the vegetable oils. Among animal oils may be ranked fat, tallow, lard, suet, butter, &c. Fish oil is generally more liquid than other animal oils. Spermaceti is an animal oil, found in the head of a species of whale.—Bones consist chiefly of phosphate of lime, with carbonate of lime, and gelatine.—Blood consists of albumen, fibrin, colouring matter, and a mild oil. The colouring matter has been supposed to depend upon iron, but Vauquelin has proved, that the most delicate test could not evince the existence of iron in it. Blood, when suffered to rest, separates into two parts, the one, a coagulum or clot, called the crassamentum; the other, a fluid, called the serum.—Milk, if suffered to rest, throws upon its surface a butteraceous oil, called cream. If the remaining skimmed-milk be suffered to stand, it becomes sour, and separates into two parts: curd, which is chiefly albumen; and whey, (which is generally analogous to serum,) mixed with sugar and lactic acid.—Horn, &c. Nails, horns, hoofs, and quills, resemble coagulated albumen. Bile, urine, saliva, &c. are all animal substances of a complicated nature.

Animal *Putrefaction.* Every animal body, when deprived of life, and exposed to the air, undergoes a decomposition, or resolution of its parts. Its colour becomes pale, and then changes to blue and green; the parts become soft, and send out a putrid smell, from the discharge of noxious gas. The organization is destroyed, the constituent parts of the animal subtances form new arrangements, and are chiefly resolved into a gaseous state; and what remains is a dry powder, composed of earths and charcoal.

ANIMALCULES, such animals as are clearly discernible only by means of microscopes, for millions of millions of them might be contained in a thimbleful of water, which is the best element for studying their motions. By the microscope many kinds of animalcules have been discovered, as different from each other as the horse from the mouse; some indeed so exceedingly minute, that a million would not equal in magnitude a large grain of sand; and, as more and smaller objects have ever been discovered, in proportion to the goodness of the glasses with which they have been viewed, it is highly probable that there are numberless other species, of a size much less than those already discovered. Every drop of water, and almost any fluid, except oils and ardent spirits, either does or will, by standing exposed a few days in warm weather, swarm with living creatures. Some seem natural inhabitants of the fluids in which they are found; others live there only occasionally, in the manner of gnats, which, from eggs dropped in water by their parents, become swimming animals; but, after a short time, shed their skins, appear in a form without resemblance to that before assumed, take wing, and claim kindred with the countless millions which rejoice in the air. The largest sort are thin and transparent; they turn frequently, have many feet, often seen about the extremities; at one end are some bristles longer than the feet, resembling a tail. Their motion is swift, and their frequent turns and sudden stops would intimate that they were hunting after their prey, probably insects indefinitely smaller than themselves, that have hitherto escaped notice with the best glasses. They employ their feet in both running and swimming; for, putting a hair among them, like rope-dancers, they often creep along it, bending in odd postures. The second kind are spiral or screw-like: when they lie still, they often thrust forth a fringed or bearded tongue; a small current may be discerned towards them, probably caused by the nimble motion of some fins or legs, too minute to be discerned. Another sort, about the same size, but without tails, resemble a flounder: their feet may be seen clearly, as the water evaporates, when they move very nimbly. The next kind appear like slender worms, about fifty times longer than broad; their waving progressive motion is equal and slow. They swim with equal facility any way; and being every where of the same thickness, it is difficult to ascertain the head. A fifth sort are so small, that an hundred in a row would not equal the diameter of a grain of sand; and consequently a million are but equal in bulk to one such particle; their shape is nearly globular. A sixth kind have also been discerned, about the thickness of the last, but twice as long. The smallest drop of sulphuric acid, only as much as will stick to the point of a pin, put among these animalcules, will cause them all to fall down dead. So eels in paste are very entertaining objects when examined by any microscope, particularly the solar one, which very plainly distinguishes the motions of their intestines; and, when the water is nearly evaporated, and they are near expiring, their mouths appear opened to a considerable width. Leeuwenhoek says, no living creatures appear in rain water fresh descended, but after standing a few days, innumerable animalcules of different species, many thousand times smaller than a grain of sand, are visible by the microscope. In summer, the water in ditches appears sometimes greenish or reddish; which, examined with the microscope, is owing entirely to the millions of animalcules crowded on the surface. Their bodies are oval and transparent, the middle parts either green or red; seem composed of globules, so similar to the roe of fish, that it is believed to be the same, especially as they are found, after some time, perfectly clear and colourless, when they may be supposed to shed their spawn. The water from dunghills is so thronged with animalcules, that it seems all alive, and must be diluted before they can be separated to distinguish their kinds.

ANNEALING, Nealing, the cooling of bottles and glass gradually by placing the materials thus blown in a furnace, in which they gradually cool. By the process of annealing, the glass is kept for some time in a state approaching to fluidity; the heat increases the bulk of the crystallized part, and renders it so soft, that the internal parts have an opportunity of expanding, and forming a regular crystallization. A similar process is now used for rendering kettles, and other vessels of cast iron, less brittle. And as iron diminishes in bulk when it passes into a fluid state, the crystals of cast iron are destroyed by the blast of an air furnace, and the mass converted into forged iron, the particles of which it is composed having arranged themselves into that form of crystals or laminæ, by which forged iron is distinguished. *See* Iron, &c.

ANNO DOMINI, the year of our Lord; the computation of time from our Saviour's birth.

ANNUAL, in Astronomy, any thing which relates to the year, or which returns yearly; as *Annual Motion of the Earth, Argument of Longitude, Epacts, Equation*, &c.

ANNUITIES, signify any interest of money, rents, or pensions, payable from time to time, at particular periods. The most general division of annuities is into annuities certain, and contingent annuities; the payment of the latter depending upon some contingency; such, in particular, as the continuance of life. Annuities have also been divided into annuities in possession, and annuities in reversion; the former meaning such as have commenced, or are to commence immediately;

and the latter, such as will not commence till some particular future event has happened, or till some given period of time has expired. Annuities may be farther considered as being payable yearly, half-yearly, or quarterly. The present value of an annuity is that sum, which, being improved at compound interest, will be sufficient to pay the annuity. To find the present value of an annuity by the following Table, we have only to find the amount for £1 at the given rate of interest, and for the given time; which multiplied by the given annuity, or payment, will be the present worth.—*Example.* What is the present value of an annuity of £40 per annum, to continue 20 years, at the rate of 4 per cent.? By the Table, the amount of £1 for 20 years, at 4 per cent. is 13·590326; therefore, 13·590326 × 40 = £543. 12*s.* very nearly.

Table.—*The present Value of £1 per Annum, and from 1 to 60 years, at any rate of Compound Interest from 3 to 6 per Cent.*

Yrs.	At 3 per Cent.	3½ per Cent.	4 per Cent.	4½ per Cent.	5 per Cent.	6 per Cent.
1	·970874	·966184	·961538	·956938	·952381	·943396
2	1·913470	1·899694	1·086095	1·872668	1·859410	1·833393
3	2·828611	2·801637	2·775091	2·748964	2·723248	2·673012
4	3·716098	3·673079	3·629895	3·587526	3·545950	3·465106
5	4·579708	4·515052	4·451822	4·389977	4·329477	4·212364
6	5·417191	5·328553	5·242137	5·157872	5·075692	4·917324
7	6·230283	6·114544	6·002055	5·892701	5·786373	5·582381
8	7·019692	6·873956	6·732745	6·595886	6·463213	6 209794
9	7·786109	7.607687	7·435332	7·268790	7·107822	6·801692
10	8·530203	8·316605	8·110896	7·912718	7·721735	7·360087
11	9·252624	9·001551	8·760477	8·528917	8·306414	7·886875
12	9·954004	9·663334	9·385074	9·118581	8·863252	8·383844
13	10·634955	10·302738	9·985648	9·682852	9·393573	8·852683
14	11·296073	10·920520	10·563123	10·222825	9·898641	9·294984
15	11·937935	11·517411	11·118387	10·739546	10·379658	9·712249
16	12·561102	12·094117	11·652296	11·234015	10·837770	10·105895
17	13·166128	12·651321	12·165669	11·707191	11·274066	10·477260
18	13·753513	13·189682	12·659297	12·159992	11·689587	10·827603
19	14·323799	13·709837	13·133839	12·593294	12·085321	11·158116
20	14·877475	14·212403	13·590326	13 007936	12·462210	11·469921
21	15·415024	11·697974	14·029160	13·404724	12·821153	11·764077
22	15·936917	15·167125	14·451115	13·784425	13·163003	12·041582
23	16·443608	15 602410	14·856842	14·147775	13·488574	12·303379
24	16·935542	16·058368	15·246963	14·495478	13·798642	12·550358
25	17·413148	16·481515	15 622080	14·828209	14·093945	12·783356
26	17·886842	16·890352	15·982769	15·146611	14·375185	13·003166
27	18·327031	17·285364	16·329580	15·451303	14·643034	13·210534
28	18·764108	17·667019	16·663063	15·742874	14·898127	13·406164
29	19·188455	18·035767	16·983715	16·021889	15·141074	13·590721
30	19·600141	18·392045	17·292033	16·288889	15·372451	13·764831
31	20·000428	18·736276	17·588494	16·544391	15·592810	13·929086
32	20·388765	19·068865	17·873551	16·788891	15·802677	14·081043
33	20·765792	19·390_08	18·146674	17·022862	16·002549	14·230230
34	21·131837	19·700684	18·411198	17·246758	16·192904	14·368141
35	21·487220	20·000661	18·661613	17·461012	16·374194	14·498246
36	21·832252	20·290494	18·908282	17·666040	16·546852	14·620986
37	22·167235	20·570525	19·142579	17·862240	16·711287	14·736780
38	22.492462	20·841087	19·367864	18·049990	16·867893	14·846019
39	22·808215	21·102500	19·584485	18·229656	17·017041	14·949075
40	23·114772	21·355072	19·792774	18·401584	17·159086	15·046297
41	23·412400	21·599104	19·993052	18·566109	17·294368	15·138016
42	23·701359	21·831882	20·185627	18·723550	17·423208	15·224543
43	23·981902	22·062689	20·370795	18·874210	17·545912	15·306173
44	24·251274	22·282791	20·548841	19·018383	17·662773	15·383182
45	21·518713	22·495150	20·720040	19·156343	17·774070	15·455832
46	24·775419	22·700918	20·884652	19·288371	17·880066	15·524370
47	25·021708	22 899138	21·042936	19·411709	17·981016	15·589028
48	25·266707	23·091241	21·195131	49·535607	18·077158	15·650027
49	25·501657	23·276564	21·341472	19·651298	18·168722	15·707572
50	25·729764	23·455618	21·482185	19·762008	18·255925	15·761861
51	25·951267	23·628616	21·617485	19·867950	18·338977	15·813076
52	26·166210	23·795765	21·747582	19·969330	18·418073	15·861393
53	26·374990	23·957260	21·372675	20·066345	18·493405	15·906974
54	26·577660	24·113295	21·992057	20·159181	18·165146	15·919976
55	26·774128	24·261053	22·108612	20·248021	18·633472	15·990543
56	26·965464	24·409713	22·219819	20·333034	18·698545	16·028814
57	27·150936	24·550418	22·326719	20·414387	18·760519	16·061919
58	27·331005	21·686123	22·429567	20·492236	18·819542	16·098980
59	27·505831	24·817800	22·528430	20·566733	18·875754	16·131143
60	27·675561	21·941731	22 623190	20·638022	18·929290	16·161428

ANNULET, a small square member in the Doric capital, under the quarter round.

ANODYNE, a medicine which eases pain, and procures sleep; as paregorics, which assuage pain; hypnotics, which procure sleep; and narcotics, which relieve by causing stupefaction.

ANOMALISTICAL Year, the period in which the earth passes through her orbit. The periodical year.

ANOMALY, in Astronomy, an irregularity in the planets, whereby they deviate from the aphelion, or apogee.

ANONA, the custard apple, cultivated in tropical climates on account of its fruit.

ANONYMOUS, in Law, the sending letters without signature, which is felony by the Black Act.

ANSÆ, the parts of Saturn's ring projecting beyond the disc.—Anser, a small star in the milky way, between the Swan and Eagle.

ANTARES, a star of the first magnitude, *Cor Scorpii.*

ANTECEDENT, in Mathematics, the first of two terms of a ratio.

ANTECEDENCE, in Astronomy, an apparent motion of a planet towards the west, or contrary to the order of the signs.

ANTESTATURE, in Fortification, a small retrenchment made of palisadoes, or sacks of earth, with a view to dispute with an enemy the remainder of a piece of ground.

ANTHELIX, the inward protuberance of the external ear, being a semicircle within, and almost parallel to the helix.

ANTHELMINTICS, medicines that destroy worms.

ANTHEMIS, camomile, medicinally aperient, carminative, emollient, and in some measure anodyne: the flowers afford a shining yellow.

ANTHERA, that part of the stamina within the corolla, that contains the pollen, which, when mature, it emits for the impregnation of the plant.

ANTHERICUM, spider wort.—Anthoceros, horn flower.—Antholyza, mad flower.—Anthospermum, amber tree.—Anthoxanthum, vernal grass.

ANTHROPOPHAGI, men-eaters, which have existed in all ages, and in many countries, where neither religion nor philosophy enlighten the savage mind.

ANTHYLLIS, kidney vetch.

ANTIDESMA, Chinese laurel.

ANTIBILIOUS Pills; aloes, scammony, Turkey rhubarb, and tartarized antimony: one grain of each makes one pill.

ANTIMONY, a mineral, so brittle as to be easily pulverized: it is of a whitish blue colour, is rarely found native, but generally combined with sulphur. Among the ancients it was in much repute as a dye for the eyelashes and eyebrows. As a medicine, it forms an emetic, when dissolved in wine and acetous acid. The tartaric acid forms with it tartar-emetic. In the arts, it is used to give the composition of burning mirrors a finer texture: it renders the sound of bell-metal more clear; mingled with tin, it makes this last harder, whiter, and sonorous; mixed with lead, it makes printing types smooth and firm; it purifies gold; and is employed in casting cannon balls.—For the brute creation, the virtues of antimony are highly extolled: it cures the measles in pigs, and purifies their blood: horses that have running heels are healed by it, by mixing one drachm of antimony with every feeding of oats you give the horse in the morning. When horses refuse it in oats, give it them in balls. Horses that look lean and scabby are soon fattened by a slight dose for two months every morning; and pigs also are fattened a fortnight sooner by having a few doses of antimony administered to them.

ANTINOUS, in Astronomy, a figure inserted into the constellation Aquila, the Eagle.

ANTIPODES, those inhabitants of the globe that live diametrically opposite to each other.

ANTIRRHINUM, snap-dragon, or calve's snout, which is recommended in leprous, scrofulous, and hydropic cases.

ANTISCORBUTICS, medicines good against the scurvy.

ANTISEPTICS, such substances as resist putrefaction; as sea salt, nitre, salt of wormwood, alum, myrrh, asafœtida, terra japonica, aloes; Jesuits' bark, camomile, pepper, ginger, saffron, sage, rhubarb; valerian, mint, angelica, ivy, green tea, horse-radish, &c.; all the vegetable substances being dried.

ANTITHESIS, in Rhetoric, a contrast or opposition of words or sentiments; and generally the favourites of young writers.

ANTONOMASIA is another figure of speech, in which, for a proper name, is put the name of some dignity, office, profession, &c.; as the king, or his majesty.

ANTLIA Pneumatica, the Pneumatic Pump, is a novel asterism, which De la Caille formed out of a few stars between Hydra and Argo Navis.

ANVIL, a smith's utensil, upon which he hammers his metal; at one end is sometimes a spike or horn, and the surface must be very smooth and flat, and so hard that a file can make no impression on it: it is mounted on a block, the stump or root of a tree. There are small anvils used by locksmiths, which stand on their benches, &c.

AORTA, the artery which rises immediately from the left ventricle of the heart, and is from thence distributed to all parts of the body, by two grand trunks ascending and descending.

ANXIETY, is a disagreeable sensation, quite different from pain, as being more obtuse, and less capable of being referred to any particular part, though frequently more intolerable than any pain. But we must take care to distinguish between anxiety in a medical sense, and that which is spoken of in common discourse. The latter does not at all depend on the state of the body, but belongs entirely to the mind; and arises from a sense of danger, or a foresight to any misfortune. The former is truly corporeal; and derives, no less than pain, its origin from a certain state of the body. Notwithstanding this difference, however, it is very possible for both these kinds of anxiety to be present at the same time, or for the one to be the cause of the other. A very great bodily anxiety will strike fear and despondency into the most resolute mind; and mental anxiety, on the contrary, if very violent and long-continued, may induce the former, by destroying the powers of the body, especially those which promote the circulation of the blood. Anxiety, in the medical sense of the word, arises in the first place from every cause disturbing or impeding the motion of the blood through the heart and large vessels near it; from diseases of the heart and its vessels, such as its enlargement, too great constriction, ossification, polypus, palpitation, syncope, inflammation, debility, and also some affections of the mind. It is likewise produced by every difficulty of breathing, from whatever cause it may arise; because then the blood passes less freely through the lungs: anxiety of this kind is felt deep in the breast. It is said also to arise from the difficult passage of the blood through the liver or other abdominal viscera. A certain kind of anxiety is very common and troublesome to hypochondriacal people; and arises from the stomach and intestines being either loaded with indigested and corrupted food, or distended with air produced by fermentation, and extricated from the aliments. By such a load or distention, the stomach, which is a very delicate organ, becomes greatly affected. Besides, the free descent of the diaphragm is thus hindered, and respiration obstructed. Anxiety of this kind is usually very much and suddenly relieved by the expulsion of the air; by which, as well as by other signs of a bad digestion, it is easily known. In these cases the anxiety is usually, though with little accuracy, referred to the stomach. Anxiety also frequently accompanies fevers of every kind, sometimes in a greater and sometimes in a lesser degree; arising as well from the general debility as from the blood being driven from the surface of the body, and accumulated in the large vessels: as in the beginning of an intermittent fever. Or it may arise from an affection of the stomach, when overloaded with crude, corrupted aliment, or distended and nauseated with too much medicated drink. As the fever increases the anxiety of the patient becomes greater and greater; remarkably so, according to the testimony of physicians, either immediately before the crisis, or on the night preceding it; as before the breaking out of exanthemata, hæmorrahagy, sweat, or diarrhœa, which sometimes remove fevers. The patient feels likewise an anxiety, from the striking in of any eruption or critical metastasis. This sensation also accompanies fevers and most other diseases, when the vital power is exhausted, and death approaches, of which it is the forerunner and the sign. It happens at that time, because the vital powers, unable to perform their functions, cannot make the blood circulate. But what kind of anxiety this is, the other signs of approaching death shew very evidently. Moreover, even in the time of sleep, anxiety may arise from the same causes: hence frightful dreams, which frequently disturb our repose with surprise and terror.

APAUMEE, in Heraldry, a hand extended, the palm open, the fingers and thumb extended.

APEPOIA, Indigestion, which may be produced by abstemiousness and excess. Columbo root infused in a teapot with boiling water, and drank when cold in the forenoon, a wine-glass full at a time, is a very excellent dose when the stomach is languid. It is prescribed in substance with any grateful aromatic, or infused in Madeira wine, now and then interposing gentle doses of tincture of rhubarb.

APERIENTS, facilitate the circulation, and remove obstructions; smallage, fennel, asparagus, butcher's broom, and parsley, are the common aperients of the shops.

APHANE, parsley root.

APHANIA, a total loss of voice, mostly the effect of other disorders, and must be removed by eradicating the disease which had caused it.

APHELIUM, that point of a planet's orbit, in which it is farthest distant from the sun.

APHIS, the vinefretter, or plant louse, of which there are thirty-three species, all of them destructive to plants.

APHTHÆ, small round ulcers in the mouth.

APHYLLANTHES, leafless flower. Blue Montpellier pink.

APIARY, a place where bees are kept. *See* Bee.

APIUM, parsley, which should be used sparingly, for it is liable to produce epilepsy in some constitutions.

APOGEE, that part of the earth's orbit which is farthest from the sun. The sun's apogee and the earth's aphelion are one and the same point.

APOGOGICAL Demonstration; *See* Absurd; an indirect way of proof, by observing the absurdity of the contrary.

APOPHYGE, a concave ring of a column, above or below a flat member.

APOPLEXY, a disease by which the patient is suddenly deprived of all his senses, and of voluntary motion

APOSCYNUM, dog's-bane.

A POSTERIORI Demonstration, proves or disproves the fact from the enumeration of particulars, as when we infer the rotundity of the earth from the circular shadow it casts on the moon.

APOSTLES' Creed, a formula of the Christian faith, occurs first in the writings of St. Ambrose; and was introduced into the church about the end of the 5th century, when Petrus Gnapheus prescribed the recital of it every time divine service was performed.

APOSTROPHE, in Rhetoric, a figure by which a person, who is either absent or dead, is addressed as if he were present, and listening to us.

APOTHECARY, one who practises the art of pharmacy; in London, the apothecaries are one of the city companies; and they are obliged to make up their medicines according to rules laid down in the college dispensatory. Their hall, in Blackfriars, is the first laboratory in the universe.

APOTHEOSIS, the absurd ceremony of making a mortal a god. A gem in the museum of Brandenburgh, represents the apotheosis of Julius Cæsar, mounted upon a celestial globe, and holding a helm in his hand, as if he were now the governor of heaven, as before of the earth.

APOTOME, in Geometry, the difference between two immeasurable lines. In Music, the difference between a greater and lesser semitone; expressed by the ratio 128 : 125.

APPARATUS, the appendages or utensils belonging to machines; as the apparatus of an air-pump, electrical machine, &c.; meaning the various detached parts which are necessary for putting the machinery in action, and for performing experiments, &c.

APPARENT, in Mathematics and Astronomy, is used to signify things as they appear to us, in contradistinction from real or true; and in this respect the apparent state of things is often very different from their real state: as is this case of distance, magnitude, &c.

Apparent *Conjunctions of the Planets,* is when a right line supposed to be drawn through their centres, passes through the eye of the spectator, and not through the centre of the earth.—And, in general, the apparent conjunction of any objects, is when they appear or are placed in the same right line with the eye.

Apparent *Diameter of an Object*, is the angle that it subtends at the eye, which diminishes as the distance increases; so that a small object at a small distance may have the same apparent diameter as a much larger object at a greater distance, provided they subtend the same or equal angles at the eye. If the objects are parallel to each other, their real diameters are, in this case, proportional to their distances. The apparent diameter also varies with the position of the object; and of equal objects at equal distances, those which stand in a position most nearly perpendicular to the line of their direction from the observer, will appear to have the greatest diameter; our idea of the apparent magnitude generally varying nearly as the optic angle. But although the optic angle be the usual or sensible measure of the apparent magnitude of an object, yet habit, and the frequent experience of looking at distant objects, by which we know that they are larger than they appear, has so far prevailed upon the imagination and judgment, as to cause this likewise to have some share in our estimation of apparent magnitudes; so that these will be judged to be more than in the ratio of the optic angles.

Apparent *Altitude of Celestial Objects*, is effected chiefly by refraction and parallax; and that of terrestrial objects, by refraction.

Apparent *Figure*, the figure or shape which an object appears under when viewed at a distance; and is often different from the true figure. Thus a straight line, viewed at a distance, may appear but as a point; a surface, as a line; and a solid, as a surface. Also these may appear of different magnitudes, and the surface and solid of different figures, according to their situation with respect to the eye: thus the arch of of a circle may appear a straight line; a square, a trapezium, or even a triangle; a circle, an ellipsis; angular magnitudes, round; and a sphere, a circle. Also all objects have a tendency to roundness and smoothness, or appear less angular, as their distance is greater: for, as the distance is increased, the smaller angles and asperities first disappear, by subtending a less angle than one minute; after these, the next larger disappear, for the same reason; and so on continually, as the distance is more and more increased; the object seeming still more and more round and smooth. So, a triangle, or square, at a great distance, appears only as a round speck; and the edge of the moon appears round to the eye, notwithstanding the hills and valleys on her surface. And hence it is also, that near objects, as a range of lamps, and such like, seen at a great distance, appear to be contiguous, and to form one uniform continued magnitude, by the intervals between them disappearing, from the smallness of the angles which they subtend.

Apparent *Motion*, is either that motion which we perceive in a distant body that moves, the eye at the same time being either in motion or at rest; or that motion which an object at rest seems to have, while the eye itself only is in motion. The motions of bodies at a great distance, though really moving equally, or passing over equal spaces in equal times, may appear to be very unequal and irregular to the eye, which can only judge of them by the mutation of the angle at the eye. And motions, to be equally visible, or appear equal, must be directly proportional to the distances of the objects moving. Again, very swift motions, as those of the luminaries, may not appear to be any motions at all, but like that of the hour-hand of a clock, on account of the great distance of the objects: and this will always happen, when the space actually passed over in one second of time, is less than about the 14000th part of its distance from the eye; for the hour-hand of a clock, and the stars about the earth, move at the rate of fifteen seconds of a degree in one second of time, which is only the 13751 part of the radius or distance from the eye. On the other hand, it is possible for the motion of a body to be so swift, as not to appear any motion at all; as when, through the whole space it describes, there constantly appears a continued surface or solid as it were generated by the motion of the object, as is the case when any thing is whirled very swiftly round, describing a ring, &c. Also, the more oblique the eye is to the line which a distant body moves in, the more will the apparent motion differ from the true one. So, if a body revolve with an equable motion in the circumference of the circle A B C D, &c. and the eye be at E in the plane of the circle; as the body moves from A to B and C, it seems to move slower and slower along the line A L K, till, when the body arrives at C, it appears at rest at K; then, while it really moves from C by D to F, it appears to move quicker and quicker from K by L to A, where its motion is quickest of all; after this it appears to move slower and slower from A to N, while the body moves from F to H: there becoming stationary again, it appears to return from N to A in the straight line, while it really moves from H by I to A in the circle. And thus it appears to move in the line K N by a motion continually varying between the least, or nothing, at the extremes K and N, and the greatest of all, at the middle point A. Or, if the motion be referred to the concave side of the circle, instead of the line K N, the appearances will be the same. All this is manifestly referable to the motions, stations, retrogradations, &c. of the planets. If an eye move directly forwards in one direction, any remote object at rest will appear to move in a parallel line the contrary way. But if the object move the same way, and with equal velocity, it will seem to be at rest. If it move the same way, with less velocity, it will appear to move backwards, with the difference of the velocities: if it move with greater velocity, it will appear to move forwards with the difference of the velocities. And when the object has a real motion contrary to that of the eye, it appears to move backwards with the sum of the velocities. The truth of all this is experienced by persons in a boat moving on water, or in a moving carriage, making observations on distant objects in motion, or at rest.

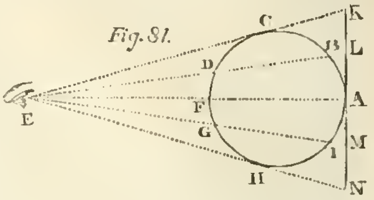


Fig. 81.

Apparent *Place of an Object*, in Optics, is that in which it appears, when seen in or through glass, water, or other reflecting or refracting media. In most cases, it differs much from the true place.

Apparent *Station*, in Astronomy, the position or appearance of a planet, or comet, in the same point of the zodiac for several days.

Apparent *Heir*, in Law, he whose right is indefeasible, provided he outlives the ancestor; as the eldest son, or his issue. Heirs *Presumptive*, are those whose right of inheritance may be defeated by the contingency of some nearer heir being born. Thus, a second son or nephew may be heir presumptive, but his right of inheritance may be defeated by the birth of a child to his elder brother or uncle; or a daughter may be heir presumptive, as her hopes may hereafter be cut off by the birth of a son, who, by the English law, succeeds to both title and inheritance.

APPARITION, in Astronomy, denotes a star or other luminary's becoming visible, which before was hid: in which sense it stands opposed to Occultation. Thus the heliacal rising is rather an apparition than a proper rising.

APPEAL, in Law, the removal of a cause from an inferior to a superior judge; as from the ordinary courts to the House of Lords.

APPEARANCE, in Perspective, is the representation or projection of a figure, or body, upon the perspective plane. *Direct* Appearance, in Optics, is the view or sight of an object by direct rays, without either refraction or reflection. In Astronomy, appearances are more commonly termed phenomena and phases.

APPLE. There are many kinds of apples; the golden pippin, which, though small, keeps well, and the tree grows well in good light soil; the Olsin pippin, or Arbroath, as to flavour, is outdone by none but the nonpareil; the Ribston pippin will keep till apples come again, and the tree grows in any situation; the golden and royal russets are handsome apples, but the nonpareil is the chief of the russets; the codlings grow freely, but none of them keep; the golden russet is a summer apple; the royal pearmain is large and beautiful.

Apple *Sauce for a Goose.* Pare, core, and slice your apples, put them in a saucepan with as much water as will keep them from burning; set them over a very slow fire. Keep them close covered till they are all of a pulp, then put in a lump of butter and sugar to your taste. Beat them well, and send them to table in a china-bason or sauce-boat, with a proper ladle.

APPLICATE: *Ordinate* Applicate, in Geometry, is a right line drawn across a curve, so as to be bisected by the diameter of it; being what we commonly call double ordinate.

APPLICATION of Geometry to Algebra, is the converse of the first of the two succeeding cases; for as in that, algebra is employed in order to obtain the solution of a geometrical problem, so in this case geometry is made use of to obtain the solution of an algebraical problem. This relates principally to the finding the roots of an equation by a geometrical construction, which is explained under the article Construction.

Application of *Algebra* and *Geometry* to *Mechanics*, consists principally in representing, by equations, the curves described by bodies in motion; as in the theory of Projectiles, &c.

Application of *Geometry* and *Astronomy* to *Geography*, principally consists in determining by geometrical and astronomical operations, the figure of the terrestrial globe; in finding the positions of places by their observed latitude and longitude; and in determining, by geometrical operations, the positions of places that are not very remote from one another. Astronomy and geography are again applicable to the theory of navigation.

APPRENTICE, one who is bound by covenant to serve a master, upon condition that he instructs or causes him to be instructed in his profession, art, or trade. Seven years is deemed the legal period; but from this there are many deviations. Several acts of parliament specify the obligations of masters and apprentices. The duties paid on indentures and premiums may be gathered from the enactments by which they are regulated.

APPROACH, in Fortification, the works thrown up by the besiegers in order to get near a fortress without being exposed to the enemy's cannon. In Gardening, it signifies the inoculating or ingrafting the sprig of one tree with another, without cutting it off the parent tree.

APPROXIMATION, in Algebra and Arithmetic, is the method of approaching nearer and nearer to the quantity sought, when there is no method of obtaining the exact value: this is the case in all rules for finding the square or cube root of any number that is not an exact square or cube.

APRICOT: of this fruit we have several kinds; as, the more-park, or peach apricot, is a large handsome fruit, by many persons thought the richest of our stone fruits; the orange apricot grows freely, and is excellent for preserving; the Breda is juicy; the Brussels, juicy and high flavoured; the masculine, though small and sharp flavoured, is the earliest apricot we cultivate.

APRIL, the fourth month of the year, according to the common, but the second according to the astronomical computation. It contains 30 days. In this month the sun travels through the sign Taurus; or more properly, the earth is now in Scorpio, and the sun, as seen from the earth, appears in Taurus.

The April *Calendar*, in animated nature, exhibits the viper and woodlouse; the mistletoe thrush pairs; frogs croak and spawn; and moths appear in the first week. In the second, the stone curlew clamours, young frogs appear, pheasant cocks crow, trouts rise, and spiders creep plentifully. In the third week, the crested wren sings; blackbirds, ravens, pigeons, hens, and ducks, sit. In the fourth, the feldfare leaves us, and the swallow returns; the nightingale sings, the bittern makes a noise; the house-martin skims the air, the blackcap whistles, and the common snake creeps abroad.—In vegetable nature, various shrubs and trees blossom, with the daffodil, hyacinth, wallflower, cowslip, periwinkle, ground ivy, beech and elm trees; and the larch shoots its wiry leaves. Nursery men now sow for fruit-trees, forests and woods, and all sorts of profitable plantations in masses; those evergreens, the pine, fir, cedar of Lebanon, holly, and yew, are planted; and all the operations of routine culture, as hoeing, road-making, draining, cropping and fencing, are performed. The gardener grafts his fruit-trees; plants cuttings of gooseberry and currant shrubs; and transplants evergreens. The flower garden is cropped, slips and offsets are propagated, insects are destroyed, and the routine culture proceeds by weeding, hoeing, &c. Pleasure grounds and shrubberies are now finished planting; lawns are formed and repaired; the fires of the green-house are discontinued. In the kitchen garden, artichokes are dressed and planted; asparagus beds are digged and forked, or sown; beans are planted and couthed up; beet, brocoli, Brussels sprouts, capsicums, carrots, leeks, celery, onions, peas, savoys, skirret, turnips, and salads, are sown; cabbages, cauliflower, German greens, potatoes, and seacale are planted. The cherry-house is forced; the grapery is strictly attended to, established plants are forced in it; the forcing peach house, and the pinery and hot beds require all the gardener's care.

Correct List of every thing in Season in April.—Meat. Beef, mutton, veal, lamb.—Fish. Carp, chub, tench, trout, crawfish, salmon, turbot, soles, skate, mullets, smelts, herrings, crabs, lobsters, prawns.—Poultry, &c. Pullets, fowls, chickens, ducklings, pigeons, rabbits, leverets.—Roots, &c. Coleworts, sprouts, brocoli, spinage, fennel, parsley, chervil, young onions, celery, endive, sorrel, burnet, tarragon, radishes, lettuces, all sorts of small salad, thyme, and all sorts of potherbs.—Fruit. Oranges, lemons, forced cherries, apricots for tarts, grapes.

A PRIORI, (*demonstration á priori,*) proves or disproves the fact from the law, or the effect from the cause; as when we deduce the immortality of the soul from the fact, that the soul is a thinking principle, and that therefore it is immaterial and indestructible.

APRON, in naval Architecture, a piece of curved timber fixed behind the lower part of the stern, and immediately above the foremost end of the keel. In Gunnery, the piece of lead that covers the touch-hole of a gun.

APTERA, the seventh order of insects, and such as have no wings.

APUS INDICA, the Bird of Paradise, a small asterism placed near the South Pole, contains eleven stars, none of which exceed the 4th magnitude.

AQUARIUS, the 11th sign of the zodiac, through which the sun moves in the month of January. Aquarius is the Egyptian Canopus or Neptune, with his pitcher. Towards the end of July Aquarius sets with his head foremost, when the Egyptians fable, that he made the river Nile overflow by plunging his pitcher into it! This constellation is bounded on the north by Equuleus and Pegasus, east by Pisces and Cetus, south by Piscis Australis and Apparatus Sculptoris, and west by Capricornus and Antinöus. There are 108 stars in this sign, four of which are of the 3d magnitude, six of the 4th, &c. The chief star *a*, of the 3d magnitude, having 1° 11′ 22″ south declination, and 329° 7′ 43″ right ascension, rises at London, on the east point of the horizon, and its rising and culminating on the first day of each month, are expressed in the following Table: Meridian Altitude 37° 17′ 38″.

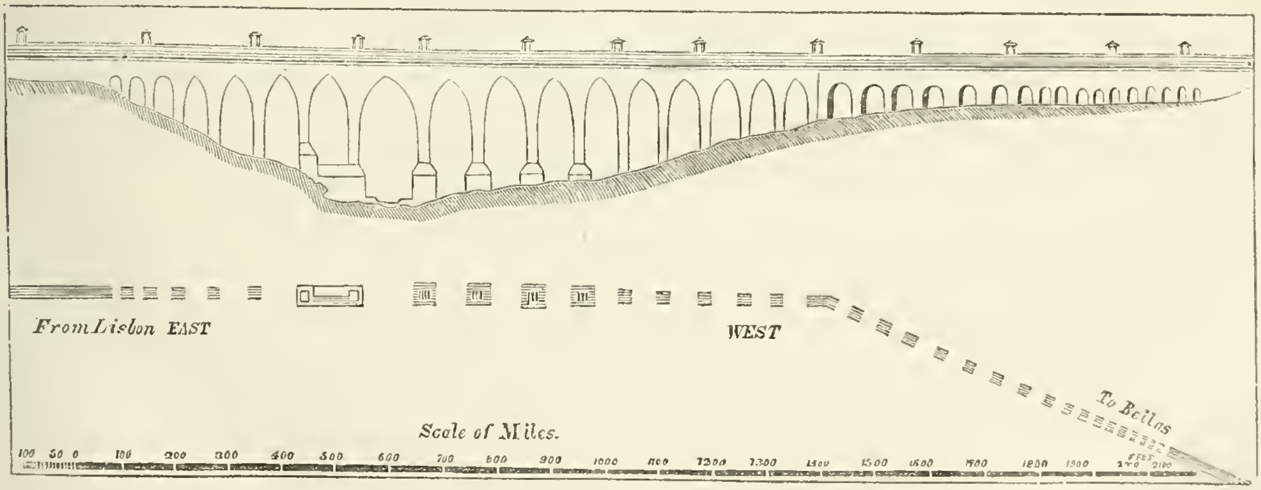
Month.	Rises. ho. mi.	Culm. ho. mi.	Month.	Rises. ho. mi.	Culm. ho. mi.
Jan.	9 17 M.	3 20 A.	July.	9 32 A.	3 12 M.
Feb.	7 0 M.	1 0 A.	Aug.	7 30 A.	1 8 M.
Mar.	5 17 M.	11 11 M.	Sept.	5 30 A.	11 13 A.
April.	3 27 M.	9 16 M.	Oct.	3 43 A.	9 28 A.
May.	1 30 M.	7 15 M.	Nov.	1 45 A.	7 33 A.
June.	11 27 A.	5 10 M.	Dec.	11 34 M.	5 28 A.

AQUA-TINTA Engraving. By aqua-tinta engraving we can produce prints resembling drawings in Indian-ink. The principle of the process consists in corroding the copper with aqua fortis, so that an impression from it has the appearance of a tint of ink laid on the paper. This is done by covering the copper with a powder or some substance which takes a granulated form, so as to prevent the aqua fortis from acting where the particles adhere, and by this means causes it to corrode the copper partially, and in the interstices only. When these particles have been extremely minute, the impression from the plate appears like a wash of Indian-ink; but when they are large, the granulation is more distinct, and as this may be varied at pleasure, it may be adapted as successfully to a variety of purposes and subjects. This powder, or granulation, is called aqua-tinta grain; there are two methods of producing it. Having etched the outline on a copper-plate, prepared in the usual way by the coppersmith, procure some substance finely powdered and sifted, which will melt with heat, and when cold will adhere to the plate, and resist the action of aqua fortis. The substances used for this purpose, either separately or mixed, are asphaltum, Burgundy-pitch, resin, gum-opal, gum-mastich; and all the resins and gum-resins answer the same purpose. Common resin has been generally used, and answers tolerably; though gum-opal makes a better grain to resist the aqua fortis. The substance intended to be used for the grain is distributed equally over the plate; different methods of performing this part of the operation have been used by different engravers. The usual way is to tie up the powder in a muslin bag, which is struck against a piece of stick, held at some height above the plate; the powder that issues out falls gently, and settles equally over the plate; as hair powder upon the furniture, after the operations of the barber. The plate being covered equally over with the dust or powder, the operator proceeds next to fix it upon the plate, by heating it gently, so as to melt the particles. This may be done by holding under the plate lighted pieces of rolled-up brown paper, moving them about till every part of the powder is melted; this will be known by its brownish change of colour. It is now to be suffered to cool, or be ready for the next part of the process. Such parts of the drawing to be engraved as are perfectly white, have their corresponding parts of the plate covered with turpentine varnish, diluted with turpentine to a proper consistence, to work freely with the pencil, and mixed with lamp-black to give it colour; if transparent, the touches of the pencil would not be distinctly seen. The margin of the plate, is also covered with varnish. When the varnish is dry, a border of wax is raised round the plate, as in etching, and you pour out the aqua fortis properly diluted with water. This is called biting-in. It is the part of the process most uncertain, and requiring the greatest degree of experience. When the aqua fortis has lain on so long that the plate, when printed, would produce the lightest tint in the drawing, it is poured off, and the plate washed with water, and dried. When dry, the lightest tints in the drawing are varnished again, and the aqua fortis poured on as before, and the same process is repeated as often as there are tints to be produced in the plate. Although many plates are etched entirely by this method of stopping-out and biting-in alternately, yet in general it is very difficult to stop round, and leave out all the finishing touches, as also the leaves of trees and other objects, which in this manner it is impossible to execute with freedom. To overcome this difficulty, another process has been invented, by which these touches are laid on the plate with as much ease and expedition as in an Indian-ink drawing. Fine washed whiting mixed with a little treacle or sugar, and diluted with water in the pencil, so as to work freely, is laid on the plate covered with the aqua-tint ground, in the same manner and on the same parts as ink on the drawing. When dry, the plate is varnished with a weak thin varnish of turpentine, asphaltum, or mastich: when dry, aqua fortis is poured on. The varnish immediately breaks up in the parts where the treacle mixture was laid, and exposes those places to the action of the acid, while the rest of the plate remains secure. The effect of this is, that all the places where the treacle was used, are bit-in deeper than the rest, and have all the precision and firmness of touches in Indian-ink. After the plate is completely bitten-in, the bordering wax is taken off, by heating the plate a little with a lighted piece of paper; it is then cleared from the ground and varnish by oil of turpentine, and wiped clean with a rag and a little fine whiting, when it is ready for the printer. The disadvantages of this method of aqua-tinting are, a difficulty to produce the required degree of coarseness or fineness in the grain, and plates so engraved print not many impressions before they are worn out, and though occasionally of service, it is therefore seldom used. The second method of producing the aqua-tint ground, generally practised, is the following. Some resinous substance, as common resin, Burgundy-pitch, or mastich, dissolved in spirits of wine, is poured all over the plate, held in a slanting direction that the superfluous fluid may drain off; it is then laid down to dry. The spirit, in evaporating, leaves the resin in a granulated state, or rather, the latter has cracked in every direction, still adhering firmly to the copper. A grain is thus produced with great ease, extremely regular and beautiful, and, in comparison of the former method, much superior for most purposes. After the grain is formed, every part of the process is conducted as described above. There are some particulars necessary to be known, to secure success in the operation. The spirits of wine used for the solution must be of the best quality, highly rectified. That sold in shops generally contains camphor, which entirely spoils the grain. Rosin, Burgundy-pitch, and gum-mastich, when dissolved in spirits of wine, produce grains of a different appearance and figure, and are sometimes used separately, and sometimes mixed in different proportions, according to the taste of the artist, some using one substance and some another. To produce a coarser or finer grain, it is necessary to use a greater or smaller quantity of resin; and to ascertain the proportions, the liquor may be poured on several spare pieces of copper, and the grain examined, before it is applied to the plate to be engraved. When the solution is made, it must stand still and undisturbed for a day or two, till all the impurities of the rosin have settled to the bottom, and the fluid is quite pellucid. No other method of freeing it from those impurities has been found to answer: straining it through linen or muslin fills it with hairs, which ruin the grain. The room in which the liquid is poured on the plate must be perfectly still, and free from dust, which whenever it falls on the plate while wet, causes a white spot, which it is impossible to remove without laying the grain afresh. The plate must also be previously cleaned carefully with a rag and whiting, as the smallest stain or particle of grease produces blemish in the grain. All these attentions are necessary, to produce regular grain; and, after every thing that can be done by the most experienced artists, there is still much uncertainty in the process. Artists are some times obliged to lay on the grains several times before they procure one sufficiently regular. The same proportions of materials do not always produce the same effect, which depends greatly on their qualities; and it is even materially altered by the weather. These difficulties are not surmounted but by experience; and those who daily practise the art, are liable to unforeseen accidents. It is to be lamented, that so elegant and useful a process should be so extremely delicate and uncertain. As the plate is held in a slanting direction, to drain off the superfluous fluid, there will naturally be a greater body of the liquid at the bottom than the top of the plate. Hence, a grain laid in this way is always coarser at the lowermost side of the plate. The most usual way is, to keep the coarsest side for the foreground, that being generally the part which has the deepest shadows. In large landscapes, various parts are sometimes laid with different grains, according to the nature of the subject. The finer the grain is, the more the impression resembles Indian-ink, and the fitter it is for imitating drawings: but fine grains are apt to come off before the aqua fortis has lain on long enough to produce the desired depth; and as the plate is not corroded so deep, it sooner wears out in printing: coarser grains, on the contrary, are firmer, the acid goes deeper, and the plate throws off a greater number of impressions. This is evident when we consider, that, in the fine grains, the particles being small are near each other, and consequently the aqua fortis, which acts laterally as well as downwards, soon undermines the particles, and causes them to come off. If left too long on the plate, the acid would eat away the grain entirely. The moderately coarse grains are on these accounts more sought after, and answer better than the fine grains formerly in use. Though there are difficulties in laying properly the aqua-tint grain, yet corroding the copper, or biting-in, so as to produce exactly the tint required, is even more precarious and uncertain. No rules can be laid down, by which success in this process can be secured; a deal of experience and attentive observation alone enable artists to do it with certainty. We will therefore give some hints which may be of importance to those who wish to obtain the practice of this art. The longer the acid remains in the copper, the deeper it bites, and consequently the darker the shade on the impression. It may be of some use, therefore, to have several bits of copper laid with aqua-tint grounds, of the same kind to be used in the plate, and to let the aqua fortis remain for different lengths of time on each; and then to examine the tints produced in one, two, three, four minutes, or longer. Observations of this kind, frequently repeated, and with acid of various degrees of strength, will assist the judgment in guessing at the tint to be produced in the plate. A magnifier is also useful, to examine the grain, and observe the depth to which it is bit. No proof of the plate can be obtained till the whole process is finished. Therefore if any part appears bit too dark, it must be burnished down with a steel burnisher; but this requires delicacy and good management, not tò make the shade streaky; and as the beauty and durability of the grain are usually injured by it, it should be avoided as much as possible. Those parts not dark enough, must have a fresh grain laid over them, and be stopped round with varnish, and subjected again to the aqua fortis. This re-biting requires care and attention. The plate must be well cleaned out with turpentine before laying on the grain, which should be pretty coarse, else it will not lay upon the heights only, as it is necessary to produce the same grain. If the new grain is different from the former, it will be rotten, not clear and fine.—In this general account of the process of engraving in aqua-tinta, we believe no material circumstance has been omitted, that can be communicated, without seeing the different stages of the operation: but after all, no written directions whatever can enable a person to practise any art perfectly, much less engraving in aqua-tinta. Its success depends upon so many niceties, an attention to circumstances apparently so trifling, that the person who attempts it, must not be surprised if he does not succeed at first. It is a species of engraving simple and expeditious, if every thing goes on well; but precarious, and liable to errors which are rectified with great difficulty. It seems adapted for imitation sketches, washed drawings, and slight subjects; but not at all calculated to produce prints from finished pictures. Nor does it appear suitable for book-plates, since it prints not a sufficient number of impressions. It cannot, therefore, be put in competition with the other modes of engraving; but, confined to subjects for which it is calculated, it is extremely useful, as it is expeditious, and may be executed with much less trouble than any other mode of engraving. But even this circumstance is a source of mischief. It occasions the production of a multitude of prints, that have no other effect than that of vitiating the public taste.

AQUEDUCT, a conduit of water, is a construction of stone and timber built on uneven ground, to preserve the level of water, and to conduct it through canals from one place to another. Some of these aqueducts are visible, and others subterraneous: those of the former sort are constructed at a great height, across valleys and marshes, and supported by piers and ranges of arches; the latter are formed by piercing the mountains, and conducting them below the surface of the earth. They are built of brick, stone, &c. and covered above with vaulted roofs, or flat stones, serving to shelter the water from the sun and rain; and of these, some are double, and others triple, that is, supported by two or three ranges of arches. Of the latter kind, are the Pont-du-gard in Languedoc, supposed to have been built by the Romans to carry water to the city of Nismes; that of Constantinople; and that which, according to Procopius, was constructed by Cosroes, king of Persia, near Petra in Mingrelia, and which had three conduits in the same direction, each elevated above the other. Some of the aqueducts are paved, others convey the water through a natural channel of clay; and it was frequently conducted by pipes of lead into reservoirs of the same metal, or into troughs of hewn stone.

The Aqueduct of *Alcantara*, fig. 83, near Lisbon, is 56,380 feet long; supported on 127 arches, the middle arch being 220 feet high, and 108 feet wide; the other arches are extremely well executed; and in standing at the western angle, the eye ranges over the piers, without the slighest variations of any of them from the vertical plane. The joints are close, and the horizontal lines well preserved. The voussoirs of the arches appear of equal length, and their extrados are adapted to the courses of 16 inches deep. Those of the middle arch appear about 8 feet in length, and 15 of them constitute the depth of the work; but the four ranks of projecting stones, which probably carried the centering, hurt the uniformity. The only perceptible sinking occasioned by the earthquake is in the north parapet, and in one of the towers. A stream, or rather winter-torrent, runs through the channel under the great arch, and empties itself into the Tagus, about two miles distant. The width of the section at top is 30 feet one inch, and at bottom 25 feet 10 inches. The steepest or eastern bank is the Lisbon side, and the gently rising or western bank, the Bellas side; the spectator will then face the south. A statue of John V. who reigned in 1717, is represented in Roman costume on a pedestal on the eastern end, where the footpath commences, from which to the arch No. 1, is 570 feet seven inches solid wall. The most modern and most extensive aqueduct is that built by Louis XIV. near Maintenon, for carrying the river Bure to Versailles. It is 7000 fathoms long, and its elevation 2560 fathoms; and contains 242 arcades.

Bridge of Alcantara.—Fig. 83.



It is a very prevailing opinion, that the Romans, amidst all their magnificence, were ignorant of the simplest elements of hydrostatics, and therefore entirely unacquainted with the method of conducting and raising water by a train of pipes. Nothing, however, can be worse founded than this notion. The ancient writers, who either treat of the subject, or incidentally mention it, are clear and explicit in their remarks, while many vestiges of art still attest the accuracy of those statements. Pliny, the natural historian, lays down the main principle, that "water will invariably rise to the height of its source:" *Subit altitudinem exortus sui.* He subjoins, that leaden pipes must be employed, to carry water up to an eminence. Palladius, in his treatise *De Re Rustica*, teaches how to find springs, by observing immediately, from the sunrise in the month of August, the vapours which hover above particular spots; and having there dug a well, he directs the water to be conducted to the farm or villa, either by a conduit constructed of masonry, or by means of pipes of lead, of wood, or even of earthenware. He allows one foot in sixty, or in a hundred, for an uniform descent. But if the ground should afterwards rise, he says, the conduit must be supported on piles or arches, or the water must be raised in leaden pipes, when it will mount just to the level of its head. But Palladius testifies his aversion to the use of lead, as apt to become covered with ceruss, and thereby rendered unwholesome, or even poisonous. This consideration had, no doubt, served to restrain the general adoption of leaden pipes among the Romans. Still, however, we may infer, from the allusions of the poets, that such pipes had come into very common use. They were not cast tubular as at present, but consisted of thin plates bent up into the form of a cylinder, and soldered along the edge. They must frequently have given way, therefore, at this seam. Horace asks, if the water which threatens in the streets to burst its lead, be purer than the rivulet that trembles and murmurs as it flows. *Epist.* I. x. 20. Ovid compares the gush of blood from the mortal wound which Pyramus, in the agony of despair, had inflicted upon himself, to the accidental rupture of a leaden pipe. *Metam.* iv. 120. Statius speaks, no doubt with poetical exaggeration, of whole rivers being discharged by such conduits. *Statius*, I. *Sylv.* Vitruvius describes the three principal modes of conveying water; but directs, as the previous operation, to trace a level *(libramentum)* on the ground. This libration was performed by the dioptron, the water-level, or the chorobates. The dioptron seems to have been a sort of quadrant fitted with sights; the water-level consisted of a tube, probably of copper, five feet long and an inch wide, turned up an inch and a half at both ends, and was adjusted till water rose equally in them; the chorobates, or perambulator, which he considered as the most accurate instrument, was composed of a rod twenty feet long, having a square and plummet attached at each extremity. Vitruvius allows only half a foot in the hundred, for the slope of an aqueduct. After the water had reached the walls of a city, it was admitted into a reservoir or castellum, divided into three distinct and equal compartments, one to feed the pools and fountains, another to supply the public baths, and a third for the accommodation of palaces and private houses. The distribution of the water was effected commonly by means of leaden pipes. The smallest of these was called a denaria, being ten feet in length, the sixteenth part of this in breadth, and weighing 120 Roman pounds. This gives, for the thickness of the lead, exactly the quarter of an English inch. In lower situations, where the stress against the sides was greater, the pipes appear to have been made proportionally stronger. The quantity of water delivered from the cisterns was regulated by the dimensions of the spouts, termed calices. These formed a series of twenty-five different kinds, which served as *moduli.* Their diameters were sometimes reckoned by ounces, or the twelfth parts of a Roman foot, but more commonly by quarter digits, or the sixty-fourth part of a foot. The quinaria seem to have been considered as the standard, and its width must have hence corresponded to the ·906 part of an English inch. The ajutate or length of all those spouts was the same, being twelve digits, or three-fourths of a Roman foot, and therefore equal to 8·7 English inches. Prony conjectures, from very probable grounds, that such was also the altitude of a column of pressure above the middle of each orifice. This estimate gives 1979 cubic feet, for the quantity of discharge of a denaria, in the space of twenty-four hours. Leaden pipes were likewise employed to carry water across vales and over eminences. But it behoved to erect, at the several incurvations, columnaria, or chimneys, to give vent to the air which might collect and gorge up the passage of the water. Such funnels required to be raised to near the height of the fountain head. Vitruvius, however, joins with Palladius and Columella, in recommending pipes of earthenware, as not only cheaper, but more wholesome, than those of lead. They could be formed thicker, if necessary, and might be farther strengthened and secured, they said, by an outer coating of lime worked up with oil. But such pipes not being glazed, it became necessary, before using them, to fill up the pores by a sort of puddling, that is, to wash their inside with favilla, or fine wood-ashes. No wonder, therefore, that the leaden pipes were held in little estimation among the ancient Romans. They seem to have been seldom used indeed beyond the limits of the imperial city, except as auxiliaries in the smaller aqueducts. When such conduits happened to be interrupted by a deep narrow vale, instead of joining them by an arch thrown over the gap, the connexion was sometimes formed by an inverted syphon of lead, carried on the one side down to the bottom, and brought up on the other. Rome was supplied by nine great aqueducts, according to Frontinus, who had been appointed curator of those magnificent works by the emperor Nerva. He added five more; and the number was afterwards augmented, by successive emperors, to twenty. Of these, the most remarkable were, 1. The Aqua Appia, thus named from its having been constructed by the censor Appius Claudius, in the 442d year of Rome, begun between the sixth and eighth milestone, made a circuit of 880 deep paces, and then proceeded by a deep subterranean drain of more than 11 miles, delivering the main body of its water in the Campus Martius. 2. The Old and New Anio, conduits so called from their bringing into Rome the waters of that river. The former began above the Tiber at the 30th milestone, and consisted mostly of a winding drain carried through an extent of about 43 miles. The latter, constructed under Nero, took a higher level, running 7543 paces above ground, and then pursuing a subterranean passage of 54,267 paces in length. 3. The Aqua Martia, which owed its formation to Quintus Martius, rose from a spring, distant 33 miles from Rome, made a circuit of three miles, and afterwards, forming a vault of 16 feet diameter, it ran 38 miles along a series of arcades at the elevation of 70 feet. It had vents perforated at certain distances, for disgorging the collected air; and the conduit was occasionally interrupted by deep cisterns, in which the water settled and deposited its sediment. It was hence remarkable for its clear green colour. *Lib.* xxx. 5. The Aqua Julia and the Aqua Tepula were brought by the same aqueduct, only in two lower conduits. 4. The Aqua Virginia, conducted by Agrippa, the patriotic lieutenant of Augustus, who laboured to improve and beautify Rome; and who, according to Pliny, formed in one year 70 pools, 105 fountains, and 130 reservoirs. It commenced at a very copious spring, in the midst of a marsh, at the distance of eight miles from the city, and ran about 12 miles, passing through a tunnel of 800 paces in length. 5. The Aqua Claudia, begun by Nero, and completed by Claudius, took its rise 38 miles from Rome; it formed a subterranean stream 36¼ miles in length, ran 10¾ miles along the surface of the ground, was vaulted for the space of three miles, and supported on arcades through the extent of seven miles, being carried along so high a level as to supply all the hills of Rome. It was built of hewn stone, and still continues to furnish the modern city with water of the best quality, which has hence procured it the name of Acqua Felice. The practice of tunnelling was begun under Augustus, who greatly extended the aqueducts. Other emperors likewise directed their attention to that important object. Trajan shewed particular solicitude in improving the aqueducts. Those works were executed in the boldest manner; nothing could resist the skill and enterprise of the Romans; they drained whole lakes, drove mines through mountains, and raised up the level of valleys by accumulated arcades. The water was kept cool by covering it with vaults, which were often so spacious, that, according to Procopius, who wrote in the time of Belisarius, a man on horseback could ride through them. So abundant indeed was the supply, as to induce Strabo to say, that whole rivers flowed through the streets of Rome. Contemplating the utility, the extent and grandeur of those aqueducts, Pliny justly regarded them as the wonder of the world. *Plin.* xxxvi. 15. The same idea is expressed by the poet Rutilius. *Rutilius in Itin.* According to the enumeration of Frontinus, the nine earlier aqueducts delivered every day 14,018 quinaria. This corresponds to 27,743,100 cubic feet. We may therefore extend the supply, when all the aqueducts were in action, to the enormous quantity of 50,000,000 cubic feet of water. Reckoning the population of ancient Rome at a million, which it probably never exceeded, this would furnish no less than fifty cubic feet, for the daily consumption of each inhabitant. In modern Rome, three aqueducts, the Acqua Feliee, Juliana, and Paulina, with some additional sources, deliver in twenty-four hours, according to the calculation of Prony, 5,305,000 cubic feet. This, shared among a population of 130,000, gives about forty cubic feet for each individual, being nearly the same comparative supply as in the period of Roman splendour. Such profusion of water altogether transcends our conceptions. The supply of London in the year 1790 was only 2,626,560 cubic feet daily; and even now, when the rivalship of the several water companies' has almost deluged the streets, it amounts only to 3,888,000 cubic feet. This quantity is abundantly sufficient for all the wants of a luxurious mass of inhabitants, equal certainly to the population of ancient Rome, where the consumption, however, was still fourteen times greater. How paltry then appears the actual supply of Paris, amounting only to 293,600 cubic feet of water in a day. It affords scarcely half a cubic foot, or thirty pounds avoirdupois, to each inhabitant in a population of 600,000. The Greeks of the Lower Empire had simplified the general mode of conducting water. This evidently appears from the practice which now prevails in supplying the city of Constantinople. The ground is levelled by means of the Terazi, a sort of inverted mason's plummet, which hangs from the middle of a cord stretched between two rods divided into inches and parts, set upright, and removed successively from one station to another. But the chief improvement consists in substituting, for the columnaria of the Romans, the Souterazi or water-balance, a sort of hydraulic obelisk or pyramid. By this ingenious contrivance, the expense of aqueducts is reduced to a fifth part. The water runs down with a gentle slope in covered drains, till it reaches an obelisk constructed of masonry; and rising up the one side, by a narrow channel, discharges itself into a basin at the top, from which again, at a level eight inches lower, it descends by a similar channel on the other side. The form of this hydraulic pyramid may be easily represented by the reader, without the aid of any diagram to assist his conception. Such auxiliary machines, which facilitate the escape of the air, and allow the water to settle, are commonly erected at intervals of about two hundred yards. The system is, in fact, only a repetition of conduits. From each separate basin, the water is distributed by orifices of different diameters, but having their centres all in the same horizontal line, three inches beneath the brim. The charge of the waterworks at Constantinople is intrusted to a body of 300 Turks and some Albanese Greeks, who form almost an hereditary profession. According to the interesting work of General Andreossy on the Bosphorus, that for the supply of a population of 600,000 is only two-thirds of a cubic foot, or about forty pounds of water per day. There still remain at Constantinople two ancient cisterns: 1. The Subterranean cistern, built of hard brick, vaulted and resting on marble columns: and 2. The cistern of one hundred and one columns, called anciently Philoxene; it consists of three rows of columns, one above another, and capable of holding five days' supply for the whole inhabitants of this spacious city.—*Leslie's Natural Philosophy.*

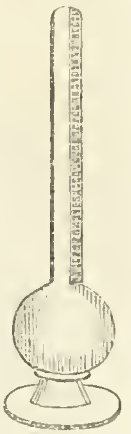
AQUILA, a constellation in the northern hemisphere, usually joined with Antinöus. According to some ancient poets, this eagle is the same as that whose form Jupiter assumed when he carried to mount Ida the beautiful Ganymede, son of Tros, king of Phrygia. Antinöus was a youth of Bithynia, (now Anatolia, in Asia Minor,) a great favourite of the emperor Adrian, who erected a temple to his memory, and placed him among the constellations. The asterism Antinöus is generally considered an integral part of the constellation Aquila. Athair, the chief star, and of the first magnitude, is situated in the eagle's neck; its right ascension is 295° 29′ 48″; and its declination is 8° 23′ 57″. It appears on the E.N.E. three-fourths east point of the horizon, at London, and rises and culminates as in the following Table: Meridian Altitude, 46° 52′ 57″.

MONTH.	RISES.	CULM.	MONTH.	RISES.	CULM.
	ho. mi.	ho. mi.		ho. mi.	ho. mi.
Jan.	6 5 M.	1 0 A.	July	6 25 A.	1 0 M.
Feb.	3 50 M.	10 35 M.	Aug.	4 25 A.	11 0 A.
Mar.	2 10 M.	8 59 M.	Sept.	2 25 A.	9 0 A.
April	12 16 M.	6 50 M.	Oct.	12 31 A.	7 15 A.
May	10 30 A.	5 0 M.	Nov.	10 35 A.	5 25 A.
June	8 25 A.	3 0 M.	Dec.	8 25 M.	3 15 A.

AQUILEGIA, columbine, the leaves, flowers, and seeds of which were formerly in great repute among the people for throwing out the small pox and measles.

ARA, the Altar, an asterism south of the Scorpion's Tail, contains nine stars, of which three are of the third magnitude, four of the fourth, &c. The chief star culminates nearly at the same time with Ras Algothi in the head of Hercules. *See* HERCULES.

Fig. 82.



ARABIS, bastard tower wall-cress.

ARABLE LANDS, those which are fit for tillage, or have been tilled.

ARACK, or INDIAN TODDY, the juice of the cocoanut tree; or a distillation of rice fermented with toddy. The Tartars have a species of arack distilled from mare's milk.

ARÆOMETER, or WATERPOISE, fig. 82, an instrument to measure the density or gravity of fluids, is usually made of glass, a round hollow ball terminating in a long slender neck, hermetically sealed at top, there being first as much running mercury put into it as will keep it swimming in an erect position. The stem is divided into degrees, and by the depth of its descent into any liquor, the lightness of that liquor is ascertained, for that fluid in which it sinks least must be heaviest: and that in which it sinks lowest, lightest. *See* HYDROMETER

ARBOR, in Mechanics, a spindle, or axis, whereon a machine turns; as, the *arbor* of a crane, a mill, &c.

ARBOR DIANÆ, or *Tree of Diana.* Half an ounce of fine silver, and two drachms of mercury, dissolved separately in a quantity of aquafortis, are then mixed together, and poured into a pint of common water, and stirred about, that the whole may be well mixed. This preparation is kept in a bottle well corked. In a glass globe, or other vessel, put the amalgam of silver with mercury, the quantity of a small nut; pour three or four ounces of the above liquor over it, and, some hours after, there will arise from the globular amalgam small branches, which, by increasing, will form a beautiful silver shrub.

ARBOR MARTIS, or *the Tree of Mars.* Dissolve iron filings in aquafortis moderately concentrated, till the acid is saturated: then add to it gradually a solution of fixed alkali, (oil of tartar per deliquium.) A strong effervescence will ensue, and the iron, instead of falling to the bottom of the vessel, will afterwards rise, and cover the sides, forming a multitude of ramifications heaped one upon the other, which will pass over the edge of the vessel, and extend themselves on the outside with all the appearance of a plant.—*Silver Tree on Glass.* Put a few drops of the solution of silver in aquafortis on a piece of glass, form a bit of copper or brass wire to represent a tree with its branches, but flat, so as to lie upon the glass; lay it in the liquid, and let it remain for an hour or two. A beautiful vegetation will be perceived all round the wire, which will nearly be covered by it. This may be preserved by washing it very carefully with water, and putting another glass over it.—*Lead Tree.* Dissolve an ounce of sugar of lead in a quart of clear water, put it into a glass decanter or globe, then suspend in the solution, near the top, a small piece of zinc of an irregular shape. Let it stand undisturbed for a day, and it will begin to shoot out into leaves, and apparently to vegetate. If left undisturbed for a few days, it becomes extremely beautiful: but it must be moved with great caution. It may appear to those unacquainted with chemistry, that the piece of zinc actually puts out leaves; but this is a mistake; for if the zinc be examined, it will be found nearly unaltered. This phenomenon is owing to the zinc having a greater attraction for oxygen than the lead has, consequently, it takes it from the oxyde of lead, which re-appears in its metallic state.

ARBUTUS, or BEARBERRY. Its leaves are employed either as a powder or decoction, in gravelly complaints. Boiled in an acid, these leaves will dye brown.

ARCADE, an opening in the wall of a building formed by an arch: thus, in London, there is the Burlington arcade; the Royal arcade, a dismal passage behind the Opera House.

ARCH, a portion of the circumference of a circle, or curved line; yet arches are sometimes straight lines, as the beautiful arches of the portico of St. Andrew's Church, Glasgow, than which there is not a finer piece of architecture in the kingdom. *Triumphal* ARCHES are magnificent entries into cities; as the arch of Titus *(see the Plate,)* and that of Constantine, at Rome; the gate of St. Dennis, Paris, &c.

In fig. 84, A S′ E S B is the ponderating arch; A or B the spring of the arch; D its crown; A B its span; C D its height, or versed sine, or rise; A D B the intrados, or the lower surface of the arch, (often called the *arch*); S′ E S the extrados, being in bridges the superior surface, or the roadway; F′ F the flanks or lances; the spaces above these are called the spandrells; the portions of stone resembling wedges, which lie in a course contiguous to the intrados, are called voussoirs, or arch stones; at D the key-stone: the walls or masses PQTS, P′Q′T′S′, built to support the arches, and from which they spring as their bases, are either called piers or abutments: piers, when they stand between two neighbouring arches; and abutments, when they support the arches which are contiguous to the shore: the part of the pier from which the arch springs is called the impost; the curve formed by the upper sides of the voussoirs, the archivolt; and the lines F′ S′, F S, about the flanks, in which a break is most likely to take place, the joints of the fracture.

Definition of an Arch.

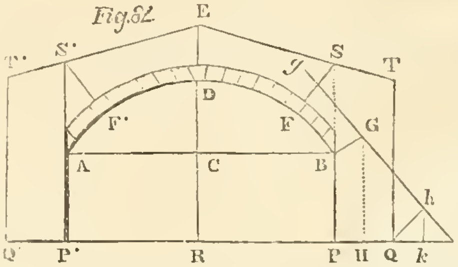


Fig. 84.

ARCHERS, the royal company of, in Scotland, are his majesty's body guards within seven miles of Edinburgh; and upon the visit of his majesty George IV. to this part of his dominions, the royal company of archers, 1000 strong, dressed in their tartan white and green, with their standards, &c. were acknowledged and received as the body guard of the sovereign, 1822. They claim this privilege by a statute of James I. 1603.

ARCHES' COURT, an ecclesiastical court of appeal, belonging to the archbishop of each province.

ARCHIL, purple rock lichen, grows upon rocks in England and Wales, and when properly prepared, imparts to woollen cloth a reddish brown; or dull, but durable crimson. It is sometimes used as a styptic.

ARCHIMEDES, of Syracuse, one of the greatest and most celebrated of the ancient mathematicians, was born in the above city about 240 years before Christ. The great and comprehensive genius of this author led him to the study of every branch of science; arithmetic, geometry, mechanics, optics, hydrodynamics, were alike the objects of his investigations, and experienced alike the powerful effects of his superior talents. To Archimedes we owe the first idea of the specific gravity of bodies, which arose out of the following circumstance. Hiero, king of Syracuse, having had reason to suspect that a goldsmith, who was employed to make him a crown of gold, had adulterated the metal by mixing with it a quantity of silver, requested Archimedes to endeavour to discover the cheat; which he did, by procuring two masses of gold and silver of equal weight with the crown, which he immersed in a vessel full of water, and carefully noticed the quantity of water which each displaced; after which, he observed how much the crown caused the same water to flow over; and on comparing this quantity with each of the former, he was able to ascertain the proportions of gold and silver in the crown. He is the reviver at least of the Egyptian mechanics.

ARCHIMEDES' SCREW, fig. 85, or the water snail, is a machine for raising water, consisting of a flexible tube rolled in a spiral form round a cylinder, as in the figure. The water enters at C, and descends at first in the spiral canal by its specific gravity, but the cylinder being turned, the water moves to E, into the canal, to occupy the lowest place; and thus by the continual rotation, it passes up to H, O, G, F, &c. to D, where it is to be discharged. The machine is turned by the winch K; the prop I R supports it, and the extreme axis is fixed in a socket P.

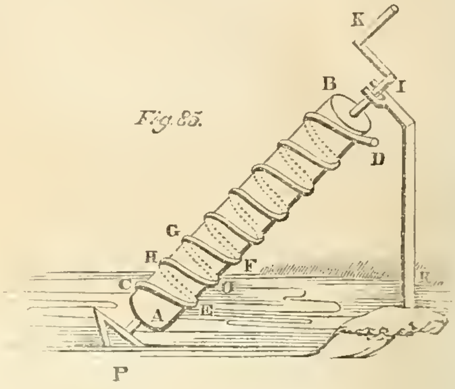


Fig. 85.

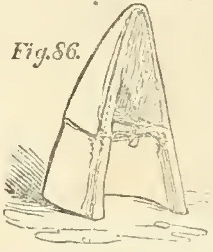


Fig. 86.

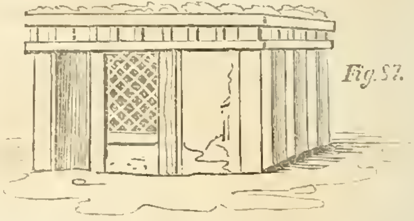


Fig. 87.

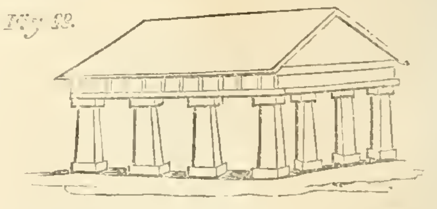
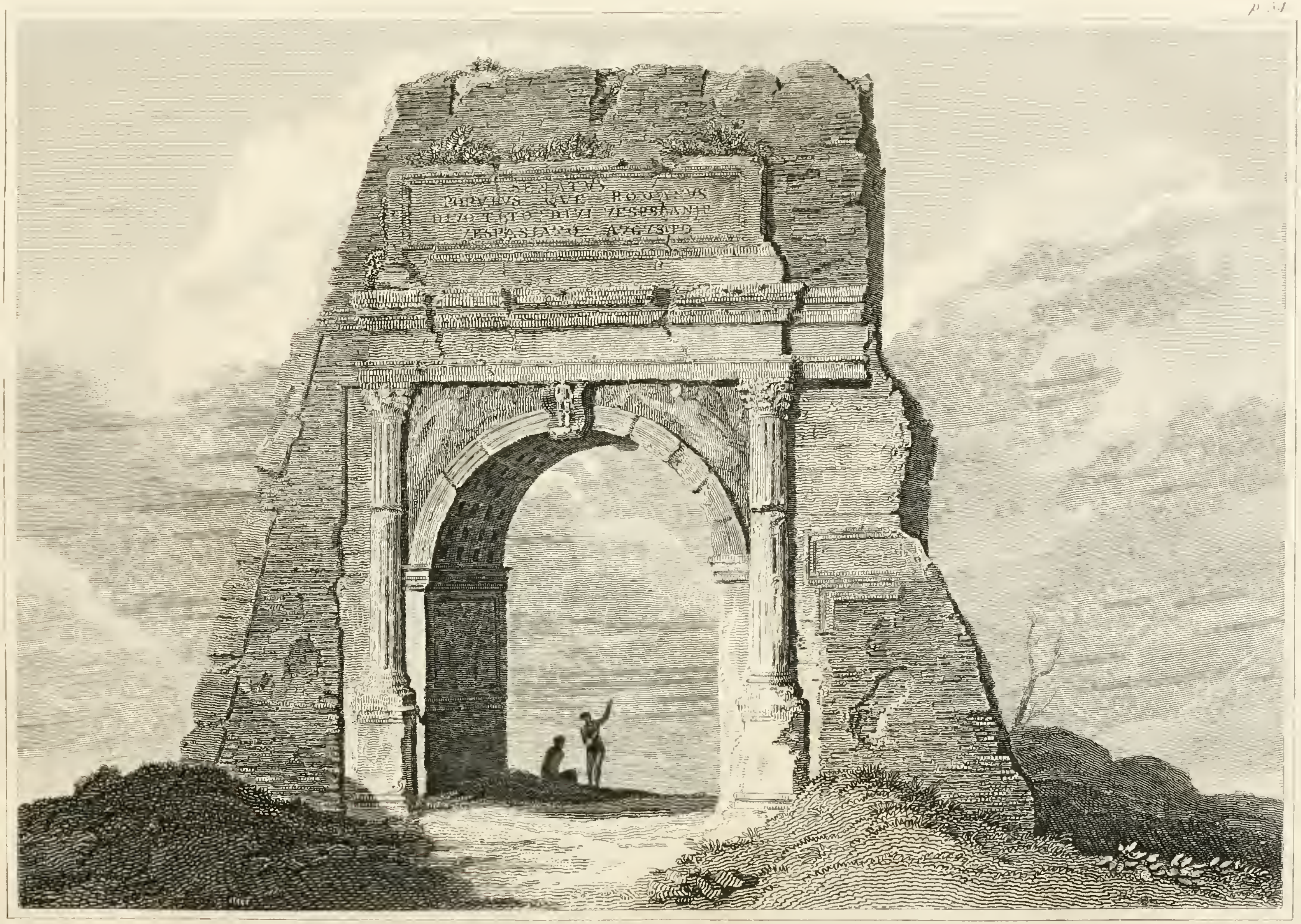


Fig. 88.

ARCHITECTURE, the art of Building, has from the earliest periods of society been cultivated by mankind; and the origin of all buildings may be deduced from the construction of the meanest huts. These were, at first, made, as fig. 86, in a conical figure, which is the simplest in structure, but being inconvenient on account of its inclined sides, both the figure and construction of the huts were changed, by giving them the form of a cube. Mankind at length improved in the art of building, and invented methods of rendering their habitations durable and convenient. The trunks of trees, deprived of their bark and other inequalities of surface, were raised above the humid soil by means of stones, and covered each with a flat stone or slate, as fig. 87, to exclude the rain; and the insterstices between the ends of the joints were closed with wax or clay. The roof was altered, and elevated in the centre by rafters, to support the materials of the covering, and to carry off the water. When the rude builder erected more stately edifices, he imitated those parts which, from necessity, had composed the primitive huts The upright trees, with stones at each end, became the origin of columns, bases, and capitals; and the beams, joists, and rafters, as fig. 88, which formed the covering, gave rise to architraves. friezes, and cornices. The Greeks, whose genius prompted them to combine elegance and convenience, derived their ideas of building from the Egyptians. But the mind of man is influenced by the government under which he lives; the Greeks, with their independence, lost the ascendency in works of genius, and

p. 54



THE TRIUMPHAL ARCH of TITUS in ROME.

ARCHITECTURE, PL. I.

TUSCAN.

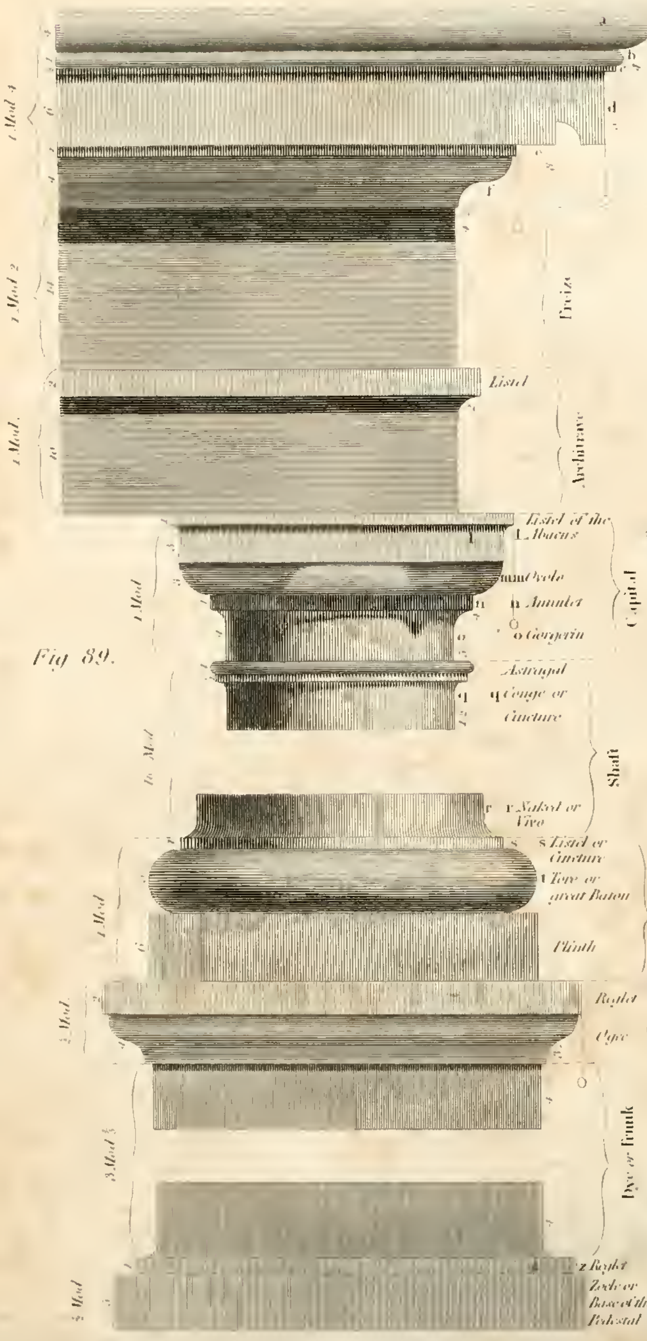


Fig. 89.

ORDER Entire.

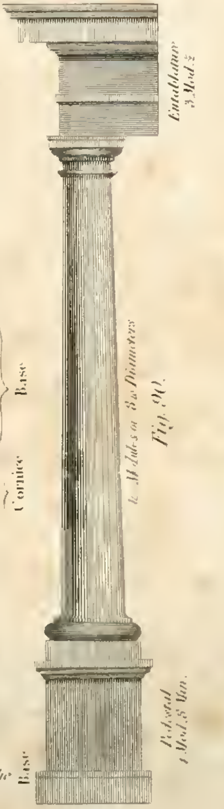


Fig. 90.

DORIC.

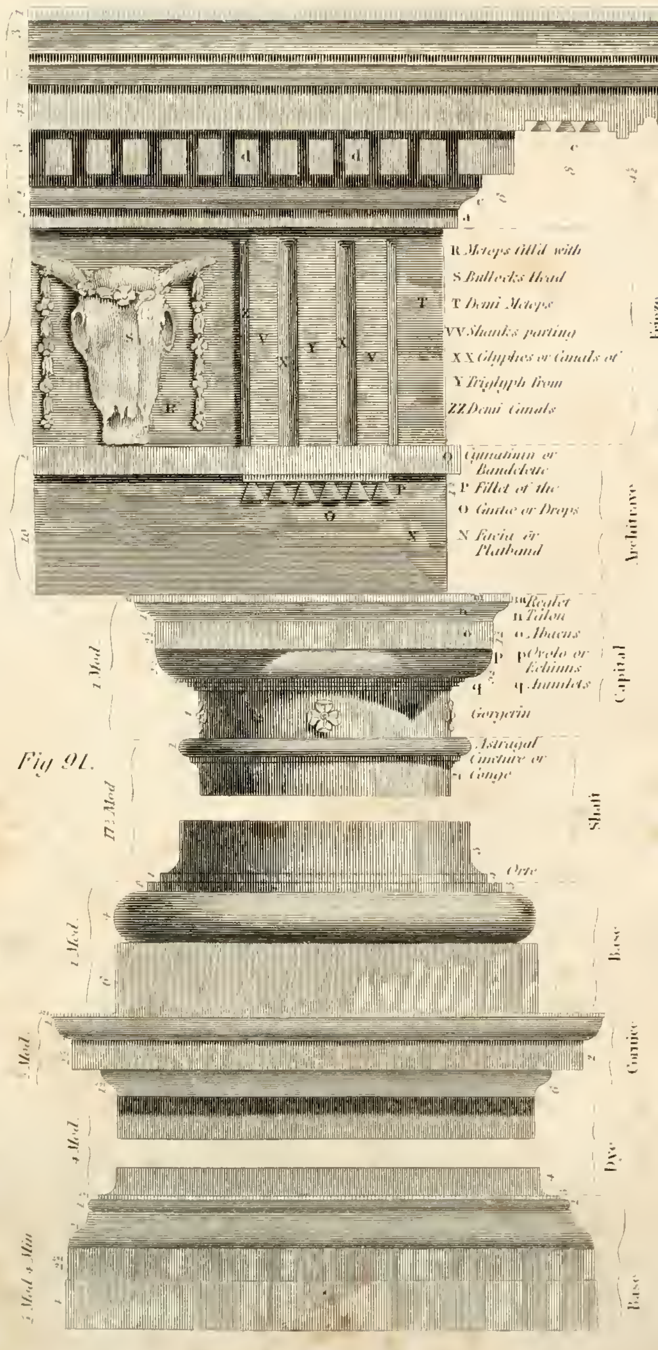


Fig. 91.

ORDER Entire

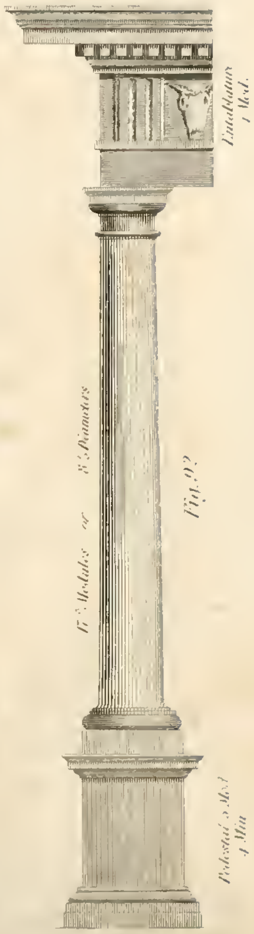


Fig. 92.

Published by H. Fisher, Caxton, London, May 1825.

IONIC ARCHITECTURE, PL. II. MOULDINGS

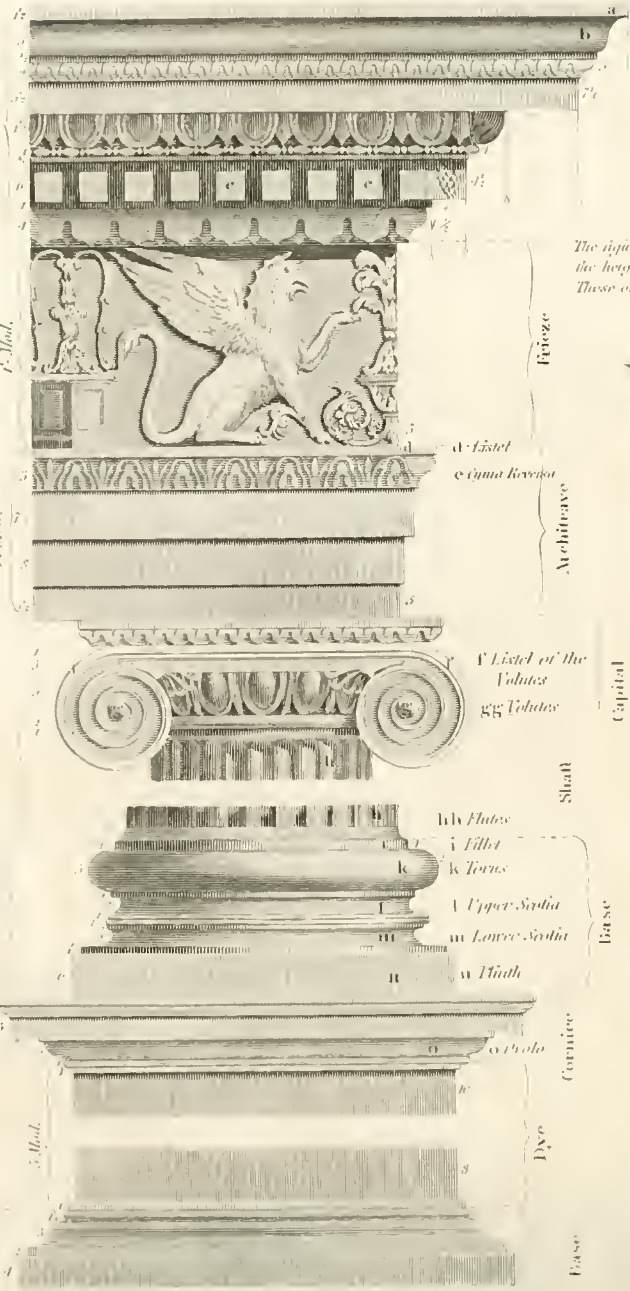


Fig. 93.

The figures on the left hand shew the heights of the Mouldings. Those on the right hand their projection

ORDER, Entire

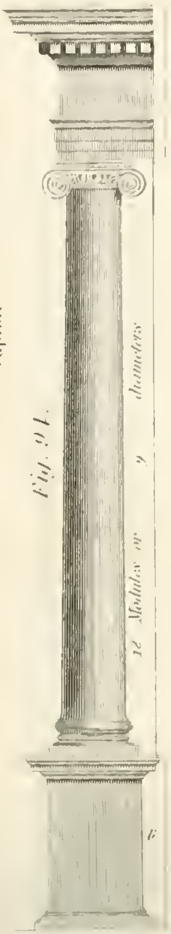
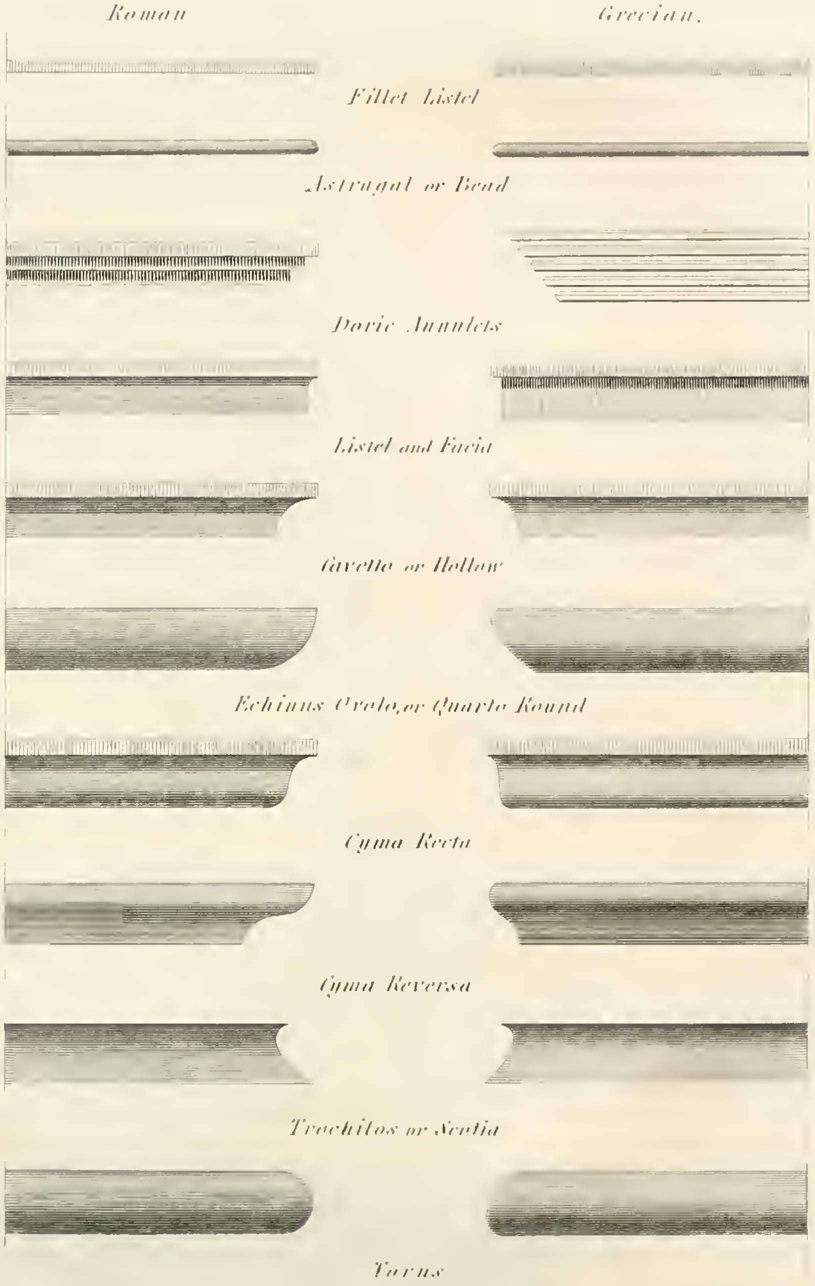


Fig. 94.



CORINTHIAN

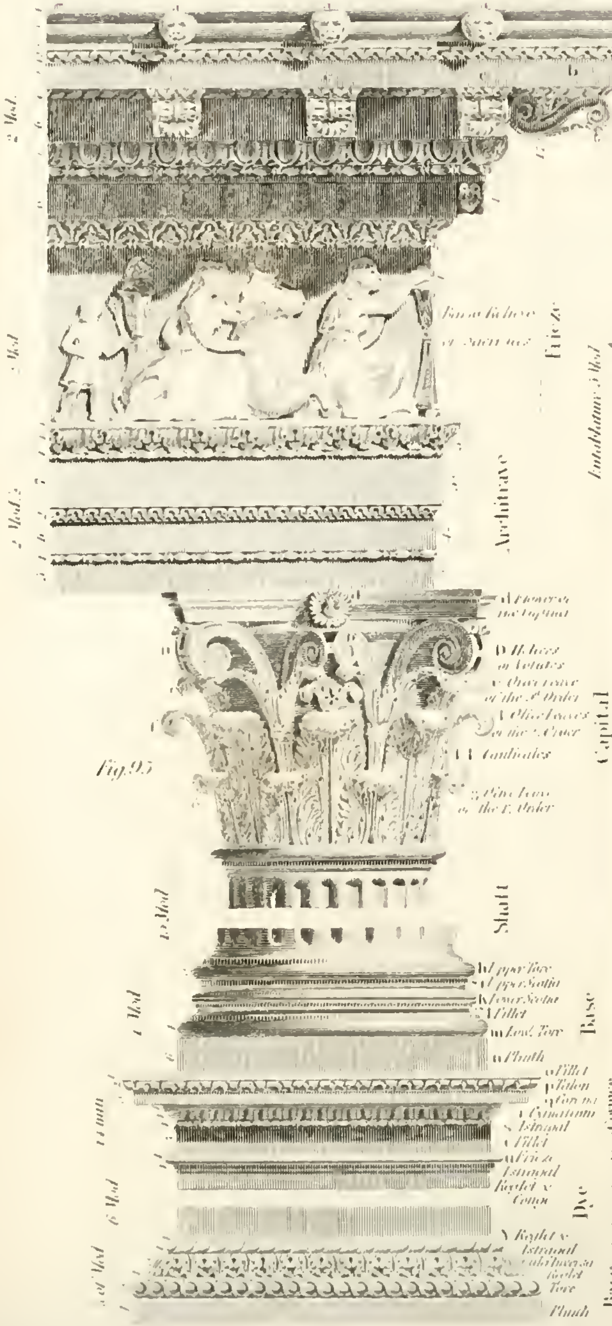
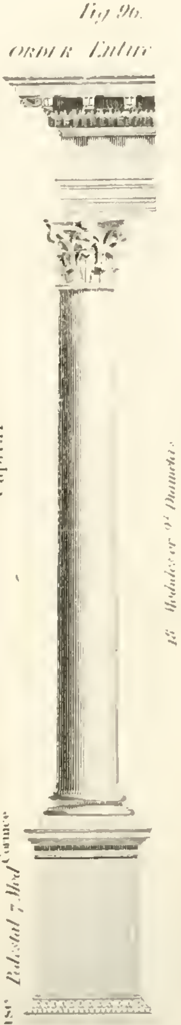


Fig. 95.

Fig. 96.

ORDER Entire



COMPOSITE

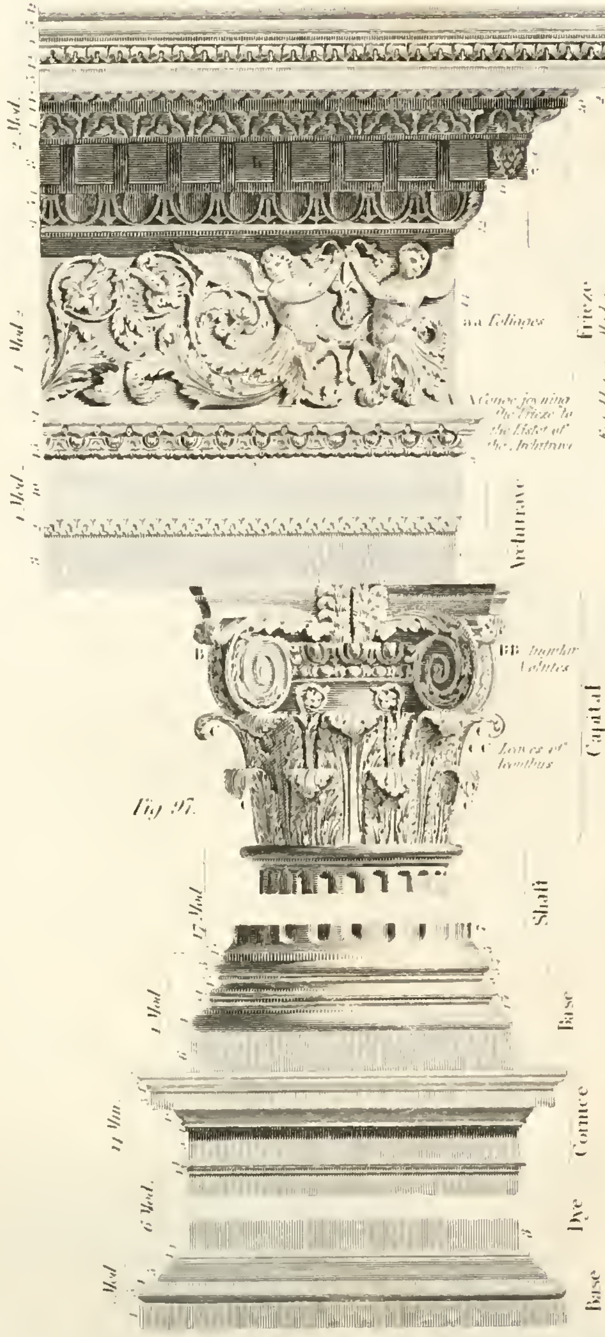
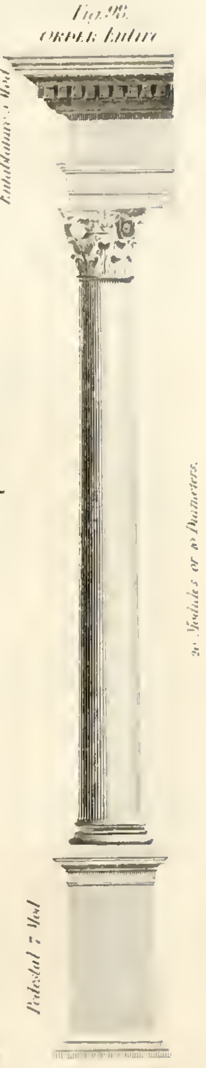


Fig. 97.

Fig. 98.

ORDER Entire

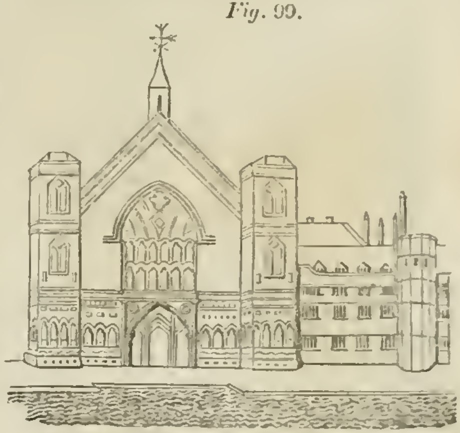


from that period the Romans encouraged this noble art. Vitruvius, the learned Roman architect, had Julius Cæsar and Augustus for his patrons, and though employed in few works of magnificence, his rules for architecture were highly esteemed by the ancients, and are still a standard among the moderns. The Romans carried to the highest perfection the five orders of architecture: the Tuscan, the Doric, the Ionic, the Corinthian, and the Composite; and though the moderns have materially improved the general structure of buildings, nothing has been added to the beauty and symmetry of these columns. To give an idea of the Orders, it must be observed, that the whole of each is divided into two parts at least; the column and entablature: and of four parts at most, when there is a pedestal under the column, and an acroter at, or little pedestal, surrounded by, the entablature: that the column has three parts, the base, the shaft, and the capital; the entablature has three likewise, the architraves, the frieze, and the cornice.

Orders of Architecture. (See Plates I. II. III.)—The *Tuscan* Order has its name and origin in Tuscany, first inhabited by a colony from Lydia, whence it is likely the order is but the simplified Doric. On account of its strong and massive proportions, it is called the Rustic order, and is chiefly used in edifices of that character composed of a few parts, devoid of ornament, and capable of supporting the heaviest weights. The Tuscan order will always live where strength and solidity are required. The Etruscan architecture is nearly allied to the Grecian, but possesses an inferior degree of elegance. The Trajan column at Rome, of this order, is less remarkable for the beauty of its proportions, than for the admirable pillar with which it is decorated. Its column is seven diameters high; and its capital, base, and entablature, have but few mouldings or ornaments. All its parts are defined in the Plate, fig. 89; and fig. 90 represents the order complete.—The *Doric* Order, so called from Dorus, who built a magnificent temple in the city of Argos, and dedicated it to Juno, is grave, robust, and of masculine appearance, whence it is figuratively termed the Herculean order. The Doric possesses nearly the same character for strength as the Tuscan, but it is enlivened with ornaments in the frieze and capital. In various ancient remains of this order, the proportions of the columns are different. Ion, who built a temple to Apollo in Asia, taking his idea from the structure of man, gave six times the diameter of the base for the height of the column. Of this order is the temple of Thesus at Athens, built ten years after the battle of Marathon, and at this day almost entire. This order has no ornament on its base, or in its capital; its height is eight diameters; its frieze is divided into triglyphs and metopes. See the Plate, fig. 91, where all the parts of the order are accurately defined; also fig 92, which gives it complete.—The *Ionic* Order derived its origin from the people of Ionia. The column is more slender than the Doric, but more graceful. Its ornaments are elegant, and in a style between the richness of the Corinthian and the plainness of the Tuscan; simple, graceful, and majestic; whence it has been compared to a female rather decently than richly decorated. When Hermogenes built the temple of Bacchus, at Teos, he rejected the Doric after the marbles had been prepared, and in its stead adopted the Ionic. The temples of Diana at Ephesus, of Apollo at Miletus, and of the Delphic oracle, were of this order. Michael Angelo, contrary to all other authors, gives the Ionic a single row of leaves at the bottom of the capital. See the Plate, fig. 93, for all the parts of the order, and fig. 94, for the finished Ionic.—The *Corinthian*, the finest of all the orders, and as first used at Corinth, is expressive of delicacy, tenderness, and beauty. The capital, so rich and graceful, was suggested to Callimachus by an acanthus entwining its leaves around a votive basket that adorned the grave of an illustrious young lady. This order marks an age of luxury; and the introduction of groups of figures into the frieze of the entablature, shews that pomp and splendour had become predominant passions, but had not yet extinguished a taste for the sublime and beautiful. The double rows of leaves, and eight volutes sustaining the abacus, and modillions in its cornice, are all very fine. The column is 10 diameters high. See Plate, fig. 95, for all the parts; fig. 96, for the entire Corinthian order.—The *Composite* Order, invented, it is said, by the Romans, partakes of the Ionic and Corinthian orders, but principally of the latter. Its column is 10 diameters high, and its cornice has denticles or simple modillions. The Plate exhibits all the parts in fig. 97; and in fig. 98, the order complete.

Saracenic, or Gothic architecture, had numerous and prominent buttresses, lofty spires and pinnacles, large and ramified windows, ornamental niches and canopies, with sculptured saints and angels, delicate lace-work, fretted roofs, and an indiscriminate profusion of ornaments. The fretwork is so called from the Saxon word *frattan*, signifying fishes' teeth. But its most distinguishing characters are small clustered pillars and pointed arches, formed by the segments of two intersecting circles. This style was of Arabian origin, introduced into Europe by the Crusaders; or those who made pilgrimages into the Holy Land. In the reign of Henry III. many of the old buildings were pulled down to give place to new ones on this model. The cathedral of Salisbury was begun early in this reign, and finished in 1258. It is one of the finest productions of ancient architecture in this island, and is completely and truly Gothic. This term, however, is used by the ignorant, to designate the barbarous compounds we sometimes see set up in imitation of the true Gothic.

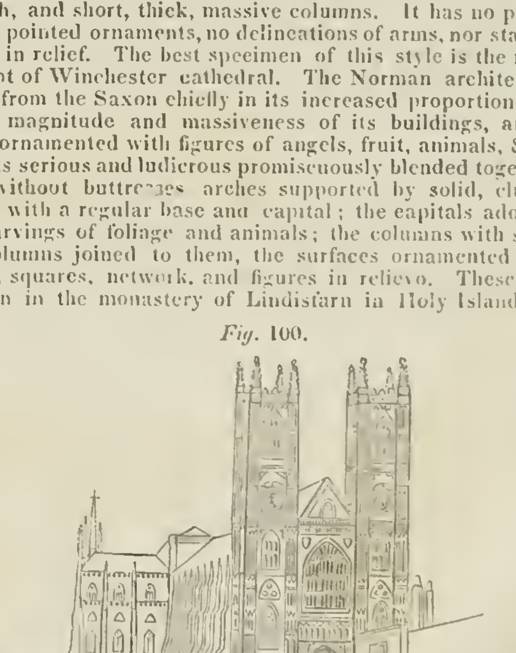
Fig. 99.



Westminster Hall.

The Saxon architecture, of which we have some remains, was the Roman architecture in a decayed state. The style of building practised throughout Europe was of this kind, and so continued to be used by the Normans, with some trifling alterations, till the introduction of the Saracenic architecture about the reign of Henry II. The characteristics are, the semicircular arch, and short, thick, massive columns. It has no pinnacles or pointed ornaments, no delineations of arms, nor statues, except in relief. The best specimen of this style is the north transept of Winchester cathedral. The Norman architecture differs from the Saxon chiefly in its increased proportion, and in the magnitude and massiveness of its buildings, arches highly ornamented with figures of angels, fruit, animals, &c.—subjects serious and ludicrous promiscuously blended together; walls without buttresses arches supported by solid, clumsy pillars, with a regular base and capital; the capitals adorned with carvings of foliage and animals; the columns with small half columns joined to them, the surfaces ornamented with spirals, squares, network, and figures in relievo. These may be seen in the monastery of Lindisfarn in Holy Island, the

Fig. 100.

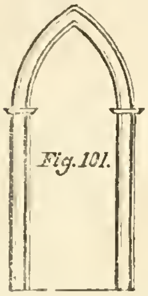


Westminster Abbey.

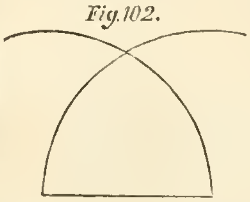
cathedral at Durham, the ruined choir at Orford in Suffolk, and in the crypt or under-croft of Canterbury cathedral.

The Florid Gothic, fig. 101, was admirably adapted for decorative sculptured monuments, screens, altar-pieces, elaborate canopies, ornamental pinnacles, octagonal niches and stalls, with the crocket ornament stealing up the angle, the pyramidal point, crowned with a large flower or a pineapple.

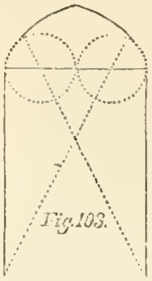
Common Gothic Arch.



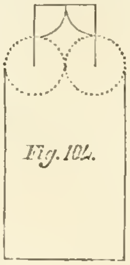
Method of Describing a Gothic Arch.



Gothic Arch, from Four Centers.

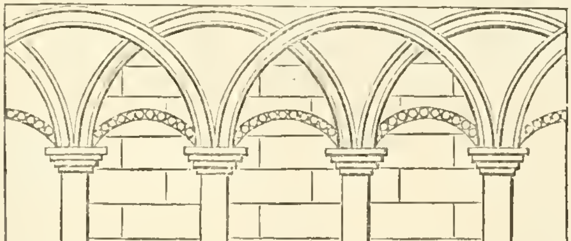


The arch, as it was described from two points, fig. 102, or from four points, figs. 102 and 103, possessed much grace for pendant decorations of fruits, flowers, and emblazonry. Moreover, sculptures of small imageries in the fretted roofs, characterized this style. The 13th century was the grand era of Gothic luxury, when, and in the succeeding century, were erected the nave and west front of York cathedral, Litchfield cathedral, St. Stephen's chapel, Westminster, (now the House of Commons,) Merton and New College, Oxford. Painted and stained glass now added much to the magnificence of the Gothic windows in those sublime structures. At the western painted window in the church of Batalha, in Portugal, the fathers usually assemble in the choir to chant the evening service, whilst the myriads of variegated rays which emanate from this beautiful window, resemble so many beams of glory playing around them. But the use of glass is of early origin in churches, for the monastery of Wearmouth was glazed in 647; and the windows of York and Canterbury cathedrals, so celebrated for their magnificence, are of early date. During the 13th and 14th centuries, most of the exteriors of our Saxon and Norman churches, as fig. 105, were transformed into the Gothic, which completed the victory of this over every other style in the kingdom. From the end of the 14th century, no remarkable variation can be discovered. Gothic architecture, at this period, had been at its height for nearly two centuries. When Henry VIII. began the Reformation, and the dissolution of monasteries took place, the two universities were at first included in the general ruin; these edifices, however, sacred to science as well as to religion, were saved from that dilapidation which many of the monasteries and cathedrals experienced. The desolating hands of those reformers who succeeded Henry VIII. destroyed many of the most beautiful specimens of this style of architecture, and despoiled them of their most beautiful ornaments. Castellated Gothic was generally used in that age, when the feudal system rendered it necessary that noblemen should possess fortified castles. This style resembles the original Saxon and Norman architecture.



Contrasted Gothic Arch.

Saxon Architecture.—Fig. 105.



Modern Architecture.—Gothic architecture began to decline from the time of Henry VIII. A style, in which the Grecian and Gothic were mixed together, then prevailed; but in the 16th and 17th centuries the chaste architecture of the Greeks and Romans was revived. The first improvements took place in Italy, whence they passed into other parts of Europe; and though the Italians were long accounted the first architects, England produced Inigo Jones and Sir Christopher Wren, who hold the most exalted station. The banqueting-house at Whitehall, queen Catherine's chapel at St. James'; the piazza of Covent Garden, and many other public buildings, are monuments of the taste and skill of Inigo Jones. The churches, royal courts, stately halls, magazines, palaces, and public structures, designed by Sir Christopher Wren, are proud trophies of British talent. If the whole art of building were lost, it might be again recovered in the cathedral of St. Paul, and in that grand historical pillar, called the Monument. To these, we superadd Greenwich Hospital, Chelsea Hospital, the Theatre at Oxford, Trinity College Library, and Emanuel College, Cambridge; the churches of St. Stephen in Wallbrook, St. Mary-le-bow, and *fifty-two* others in London, serve to immortalize his memory. While we contemplate these, and many other public edifices erected and repaired under his direction, we are at a loss which most to admire—the fertile ingenuity, or the persevering industry, of the artist. The architectural history of the 18th century differs from that of preceding ages in two essential circumstances. The public buildings erected during this period are, in general, not so grand and massive as those of some former periods. But while they fall short of splendour and magnificence, they are superior to most ancient structures in simplicity, convenience, neatness, and elegance. Private dwellings have been made more spacious, convenient, and agreeable to a correct taste, than in any preceding period. The liberal use of glass, in modern buildings, contributes greatly to their beauty and comfort, and is a point in which the ancients were totally deficient. In descending to the various minute details of human dwellings, especially those which have reference to elegance and enjoyment, it is obvious the artists of the 18th century exceeded all others. During the reign of his present gracious Majesty, the artificer and architect have had the fullest scope for the exercise of their respective talents, whether we consider the vast number of new churches and chapels that have been erected, and that are still building; or the extensive improvements which the metropolis has undergone. But all these are outdone by the buildings in the New

Stepney New Church.—Fig. 106.

Town of Edinburgh, and in Glasgow, where the whole of the very magnificent and classical edifices that have been reared, are constructed of durable free-stone, and decorated in a style that does equal honour to the genius of the people, and the spirit of the age. It would be impossible in this work to enumerate and describe the new churches which have been built since the year 1818. We may, however, give as a specimen *Stepney New Church*, fig. 106, which will hold 1500 persons, two-thirds being in free sittings.

Architectural Ornaments.—Balusters are pillars of wood, stone, and used to ornament the tops of buildings, and to support railing; when continued, they form a balustrade: Caryatides, figures of women dressed in long robes after the Asiatic manner, to support entablatures in buildings. Other female figures have been used for a similar purpose, but the original name is still retained. A war had been carried on by the Athenians against the Carians; the latter were totally vanquished, their wives were made captives, and to commemorate this event, trophies were made by the Athenians, in which figures of women, habited in the Cryatic manner, were used for the purpose just explained, and this is in fact the origin of this part of architecture. Persians, so called from a victory gained over the Persians by Pausanias, who having brought home prisoners, spoils, and trophies to the Athenians, they chose Persian male figures to support the entablatures which have been changed in the same manner as the Caryatides. Persians may be of another size; the larger, the greater the effect which they impress on the spectator's mind. In arsenals, galleries of armour, &c. they are advantageously used. Pilasters have their bases, capitals, and entablatures, the same as those of columns but are square, not round as columns are. A Portico is a range of columns covered at the top; that of Palmyra was 4000 feet long. Termini, figures anciently used to mark the limits of possessions, are still used in the human shape as ornaments for temples and garden edifices. There are many other architectural terms, which will be found described under their respective names. See the annexed Plate.

In the *practice of Architecture*, every gentleman is guided by circumstances; but the choice of situation seems to be dictated, in most cases, by the nature of things. A farmer ought to dwell in the centre of his farm; a man of fortune builds for health, neighbourhood, prospect, situation, &c. As regards the construction of edifices, the distribution of apartments, &c. the rules and plans that might be given would fill many volumes; and Aquatic Buildings, Bridges, Harbours, Roofs, Arches, &c. are all described and illustrated under their respective titles, in the work.

ARCHITRAVE, that part of a column which lies immediately upon the capital, being the lowest member of the entablature; and the

ARCHIVAULT, is the interior contour of an arch or band, adorned with mouldings, running over the faces of the arch stones, and bearing upon the imposts.

ARCHIVE, a chamber in which records are kept, as the Rolls' Office, in which the archives of the Court of Chancery are kept.

ARCHYTAS, a Pythagorean philosopher, and distinguished mathematician, of Tarentum, who flourished about 400 years before Christ, and to whom Aristotle is said to have been indebted for his ethical principles and maxims. To the ingenuity of Archytas, as a mathematician, we owe the method of finding two mean proportionals, mechanically, between two given lines, with a view to the duplication of the cube; and we derive from his skill in mechanics, the invention of the screw, crane, and various hydraulic machines; flying pigeon, or winged automaton. The astronomical and geographical knowledge of Archytas is celebrated by Horace in a beautiful ode, recording also his death, which was occasioned by a shipwreck :—

> "Archytas, what avails thy nice survey
> Of ocean's countless sands, of earth and sea?
> In vain thy mighty spirit once could soar
> To orbs celestial, and their course explore;
> If here, upon the tempest-beaten strand,
> You lie confin'd, till some more lib'ral hand
> Shall strew the pious dust in funeral rite,
> And wing thee to the boundless realms of light."

ARCTIC, the North Pole, because the last star in the tail of the Little Bear is near the pole of the world.

ARCTIC *Circle*, a lesser circle of the sphere 23½° from the north pole.

ARCTIUM, burdock.

ARCTURUS, a star of the first magnitude in the constellation Arctophylax, or Boötes; see Job ix. 9. xxxviii. 32. This star is supposed to be nearer our earth than any other in the northern hemisphere.

AREA, any plane surface on which we walk, &c. or the site on which any building stands, or the superficial contents of any figure. Thus, if a field be 40 feet on each side, the contents will be 40 × 40 = 1600; or it contains 1600 little squares, each one foot, one inch, &c. every way. In fig. 107, each little □ contains 10 feet, therefore the 16 squares contain 1600 feet.

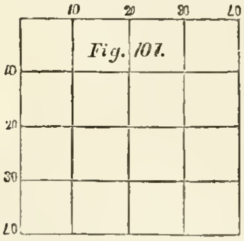


Fig. 107.

ARECA, faufel nut.

AREOLA, the colour surrounding the nipple of the breast.

AREOPAGUS, rock of Mars, a sovereign tribunal at Athens, famous for its justice and impartiality.

ARETHUSA, a marsh plant, that requires to be kept moist in two-thirds peat and one-third loam.

ARGOPHYLLUM, white leaf.

ARGO NAVIS, the ship Argo, a southern constellation, and type of the vessel in which Jason sailed from Thessaly to Colchis, on the east coast of the Black sea, to recover the golden fleece. More properly, this ship is a type of the ark of Noah. The constellation Argo Navis is bounded on the north by Monoceros and Pyxis Nautica, anciently of course by the Water Snake and the Little Dog; east by Robur Caroli, anciently by the Centaur; south by Piscis Volans and Equuleus Pictorius; and west by Canis Major and Columba Noachi. There are sixty-four stars in Argo, reckoning by the Britannic Catalogue, *viz.* one of the 1st magnitude, six of the second, nine of the 3d, nine of the fourth, &c. The brilliant Canopus, situated near the keel, has 52° 36′ south declination, and its right ascension in time is 6 ho. 20′ 1″, or 95° 15′, and though invisible in our northern latitude, it culminates as follows :—

MONTH.	CULM.	MONTH.	CULM.	MONTH.	CULM.
	ho. mi.		ho. mi.		ho. mi.
Jan.	11 31 A.	May	3 47 A.	Sept.	7 36 M.
Feb.	9 24 A.	June	1 41 A.	Oct.	5 27 M.
March	7 31 A.	July	11 36 M.	Nov.	3 22 M.
April	5 37 A.	Aug.	9 32 M.	Dec.	1 49 M.

A small part of the Ship's poop only appears above the horizon of Britain, and it is superfluous therefore to trace any combinations among the stars of this constellation.

ARGUMENT, in Astronomy, is in general a quantity upon which another quantity or equation depends, or some circumstance relating to the motion of a planet; or it is an arch, whereby we seek another unknown arch, bearing some proportion to the first: hence,

ARGUMENT of *Inclination*, or *Argument* of *Latitude*, of any planet, is an arch of a planet's orbit, intercepted between the ascending node and the place of the planet from the sun, numbered according to the succession of the signs.

Annual ARGUMENT of the *Moon's Apogee*, or simply *Annual Argument*, is the distance of the sun's place from the place of the moon's apogee; that is, the arc of the ecliptic comprised between those two places.

ARGUMENT of the *Parallax*, denotes the effect it produces on an observation, and which serves for determining the true quantity of the horizontal parallax.

ARGUMENT of the *Equation* of the *Centre*, is the anomaly, or distance, from the apogee or aphelion; because this equation is calculated in an elliptic orbit for every degree of anomaly, and varies according to the variation of the anomaly.

ARIES, ♈, the Ram, or Lamb, the first of the zodiacal signs; agreeably to the fixed zodiac of Hipparchus; when the sun enters Aries on the 20th of March, and the vernal equinox begins. From this point we reckon the right ascension of the stars, and the longitudes of the celestial bodies. The fact is, the earth is at this season of the year in Libra, and the sun, as seen from the earth, appears in Aries. The boundaries and contents of this constellation are, north by Triangula and Musca, east by Taurus, south by Cetus, and west by Pisces. This sign contains 66 stars, *viz.* one of the 2d magnitude, one of the 3d, two of the fourth, &c. The chief star in Aries, called *a Arietis*, is situated in his forehead. Its declination is 22° 36′ 30″, and its right ascension 29° 15′ 30″. It rises on the N. E. ½ E. point of the compass, at London, and culminates on the first day of each month, as in the following Table: Meridian Altitude, 6° 5′ 30″.

Month.	Rises.	Culm.	Month.	Rises.	Culm.
	ho. mi.	ho. mi.		ho. mi.	ho. mi.
Jan.	11 0 M.	7 15 A.	July	10 50 A.	7 5 M.
Feb.	8 37 M.	5 0 A.	Aug.	9 0 A.	5 5 M.
Mar.	6 45 M.	3 15 A.	Sept.	7 0 A.	3 8 M.
April	4 56 M.	1 15 A.	Oct.	5 15 A.	1 18 M.
May	3 0 M.	11 30 M.	Nov.	3 20 A.	1 30 A.
June	1 0 M.	9 30 M.	Dec.	1 15 A.	9 30 A.

ARISTÆUS, an eminent geometrician of Crotonia, who lived 330 years before Christ; and was author of five books on the Conic Sections, which, however, have never been transmitted down to us, though those of his contemporary Menechmus, have been preserved.

ARISTARCHUS, a celebrated Greek astronomer and philosopher, born at Samos, flourished about the middle of the third century before Christ. Aristarchus is well known to have maintained the modern opinion with regard to the motion of the earth round the sun, and its revolution about its own centre or axis. He also taught, that the annual orbit of the earth is but merely as a point, compared with the distance of the fixed stars. He determined the distance of the sun from the earth, and concluded, that it contained at least 18 or 20 times that of the moon from the earth. Aristarchus likewise found, that the diameter of the moon bears a greater proportion to that of the earth, than that of 43 to 108, but less than that of 19 to 60; so that the diameter of the moon, according to his statement, should be somewhat less than a third part of the earth. He also estimated the apparent diameter of the sun at the 720th part of the zodiac. Besides his astronomical discoveries, Aristarchus invented a peculiar kind of hemispherical sundial. The only work of this ancient astronomer now extant, is a treatise "on the Magnitude and Distances of the Sun and Moon," published by Wallis, with his own notes, and Commandine's version at Oxford, in 1683, 8vo.

ARISTOLOCHIA, birthwort.

ARISTOTELIAN, any thing relating to the doctrines or philosophy of Aristotle.

Aristotelian *Philosophy*, the philosophy taught by Aristotle, and maintained by his followers. It is otherwise called the Peripatetic Philosophy, from their practice of teaching while they were walking. The principles of Aristotle's philosophy are: Instead of the more ancient systems, he introduced *matter*, *form*, and *privation*, as the principles of all things; but it does not appear that he derived much benefit from them in natural philosophy. His doctrines are for the most part so obscurely expressed, that it has not been yet satisfactorily ascertained what his sentiments were on some of the most important subjects. He attempted to confute the Pythagorean doctrine, concerning the two-fold motion of the earth; and pretended to demonstrate, that the matter of the heavens is ungenerated, incorruptible, and not subject to any alteration; and he supposed that the stars were carried round the earth in solid orbs.

ARITHMETIC, the science of numbers, whose several rules of Addition, Subtraction, &c. will be found under their respective heads. The marked superiority, indeed, of our present numeral system over that of the ancients, is so conspicuous, that since the time of its first introduction into Europe, nearly all knowledge of the more imperfect and obscure methods before used is obliterated and forgotten; and even the slight vestiges of these abandoned monuments, which now remain, have become so rare and difficult to be traced, either in the original works, in which they might be expected to be found, or in the commentaries and translations of later writers, that except from the scanty relation that has been given of them by Wallis, and the more recent and ample detail of Delambre, but little further information can be expected on the subject; particularly as it is now well known, that the authors of most of the early performances in which these methods were employed, have contented themselves with barely giving the results of calculations, without shewing the nature of the process, or the different steps of the operation.

ARK, a floating vessel built by Noah, about which, all beyond the account of scripture, is mere conjecture, and had much better be omitted in this work. The truth, as related under the unerring direction of the divine Spirit, is found in Genesis.

Ark *of the Covenant*, a chest in which the Israelites kept the golden pot that contained the manna, Aaron's rod, and the tables of the covenant.

ARMED, a cross-bar is said, by sailors, to be armed, when some rope yarn, or the like, is rolled about the end of the iron bar, which runs through the shot. In Heraldry, the horns, feet, beak, and talons of birds of prey, are *armed*, when of a different colour from the body. An *armed* ship is, properly, one of the government vessels. *See* Ship of War.

ARMIGER, a title of dignity to such gentlemen as are entitled to bear arms by courtesy or creation.

ARMILLARY Sphere, an artificial sphere composed of various brass circles, to illustrate the imaginary lines with which the earth is supposed to be surrounded. See *Sphere*.

ARMOUR, a defensive dress, worn to secure the body in battle, &c.; *armour cap-a-pée* consisted of a casque or helm, gorget, cuirass, gauntlets, tasses, brassets, cuishes, and covers for the legs, to which the spurs were fastened. Lastly, the horses even had their armour to cover the head and neck.

ARMOURY, a storehouse for arms; as the Tower, the arsenal of Woolwich, &c. In Heraldry, arms are marks of dignity and honour, and are, like titles, hereditary; expressing, on the field of the escutcheon, the degree, merit, and quality of the original bearers. The ancient armour was tried and proved by raising it to a sufficient height, and then letting it fall on a large stone or pavement: if it was not injured by fracture, it was good.

ARMY, a large number of soldiers, consisting of horse and foot completely armed, and provided with artillery, ammunition, provisions, &c. under the command of one general-officer, having under him a general of horse and one of foot, a major-general for every two brigades, and nearly half as many lieutenants-general.

ARNICA, leopard's bane.

AROMATIC VINEGAR, an acetic solution of camphor, oil of cloves, oil of lavender, and oil of rosemary; take a sufficient quantity of each to make it pleasant, and mix them together.

ARPENT, a measure of an 100 perches square.

ARRAIGNMENT, in Law, to call a person to answer in form of law upon an indictment; and the Array is the ranking or setting forth of a jury, or inquest of men impannelled on a cause. An Arrest, is the restraint or beginning of imprisonment of one's person, by a lawful warrant, and is either *civil* or *criminal*. When any one is arrested for a criminal offence, the officer who arrests him is bound, (by the habeas corpus act,) under heavy penalties, to deliver to the prisoner, or his agent, within six hours after demand, a copy of the warrant of commitment, in order that no one may be imprisoned from malice or revenge, or without knowledge of the charge against him. In case such copy is denied, on complaint in writing on oath, the lord-chancellor, or any of the twelve judges, provided it is a bailable offence,—or on affidavit, that a copy is denied,—can award a writ of *habeas corpus* for such prisoner to be brought immediately before him; and he is obliged to discharge the party, on receiving bail. *See* Assize.

ARRESTS, in Farriery, mangy tumors upon a horse's hinder legs, between the ham and the pastern.

ARRONDEE, in Heraldry, the curved cross, whose arms terminate in the edge of the escutcheon.

ARSENAL, a royal or public magazine, for the making or keeping of arms, naval or military furniture and equipments, &c., as the arsenal of Woolwich, of Toulon, &c.

ARSON, the malicious burning of a house, &c. of another man, which is felony at common law.

ART, the application of knowledge to practice; hence we have the terms *useful* or *mechanic*, *liberal* or *polite* arts; the former requiring manual labour principally, the latter requiring the exercise of mind more than of the hand and body.

ARTEMISIA, mugwort.

ARTERY, a conical tube, or canal, which conveys the blood from the heart to all parts of the body. *See* ANATOMY.

ARTICHOKE, a well-known plant, grown chiefly for culinary uses, and eaten with melted butter and pepper, either plain, boiled, or stewed, and added to ragouts, and highly seasoned dishes. The leaves and stalks contain a bitter juice, which, melted with an equal portion of white wine, has been successfully employed in the cure of dropsy, when other remedies have failed.

ARTICLES OF FAITH, doctrines of Christianity, allowed and established by the church for our belief. The thirty-nine articles were confirmed by royal authority in 1652. The law requires a subscription to these articles, of all persons ordained to be deacons or priests; of all clergymen inducted to any ecclesiastical living; of licensed lecturers and curates; of the heads of colleges, chancellors, officials, commissaries, and schoolmasters. Dissenting teachers are to subscribe all, except the 34th, 35th, and 36th, and part of the 20th, (and in the case of Anabaptists, except also part of the 27th,) otherwise they are exempted from the benefits of the Act of Toleration, 13 Eliz. cap. 12, 13, 14. Chas. II. cap. 4. 1 Will. III. cap. 12.

ARTIFICER, a manufacturer of any commodity, as a smith, carpenter, &c. The artificers of Rome were exempt from all personal services, and incorporated into companies, enjoying their peculiar temples and tutelar gods; but still they were treated with contempt, most of them being slaves and foreigners, whose poverty exempted them from taxes, and whose equivocal character rendered their names unfit for the censors' books, and their persons for war. How much the state of the artificer is bettered since Rome gave law to the world, the prosperity, liberty, and opulence of Great Britain sufficiently prove. Still by the English laws, artificers in wood, iron, steel, brass, or other metal, are prevented, by statute, from quitting the kingdom. And such as go abroad, and do not return on warning given by our ambassadors, shall be disabled from holding lands by descent and demise, and from receiving any legacy, &c. and be deemed aliens. A heavy penalty is also inflicted on persons seducing artificers to go abroad. Statutes, 5 Geo. I. cap. 27; 23 Geo. II. cap. 13. § 1.

ARTILLERY, the science which the officers of artillery ought to possess; or the soldiers destined for the service of guns, cannon, mortars, &c. The artillery of Britain consists of both horse and foot soldiers, whose chief rendezvous is at Woolwich.

ARTILLERY *Park*, the place in the rear of both lines of an army for encamping the artillery, which is drawn up in lines, of which one is formed by the guns; the ammunition waggons make two or three lines sixty paces behind the guns, and thirty distant from one another: the pontoons and tumbrils make the last line. The whole is surrounded by a rope fastened to stakes, defining the camp ground; and the gunners and matrosses encamp on the flanks; and the bombardiers, pontoon men, and artificers, in the rear.

ARTOCARPUS, the bread-fruit tree, grows wild in Otaheite, and other islands of the South Seas. It is about 40 feet in height, with large spreading branches, and bright green leaves, divided into seven or nine pea-shaped lobes, and loaded with large globular berries about the size of a child's head; it affords a good nourishment, and from its inner bark there are separated fine white fibres, which are woven into cloth.

ARUM, wake-robin, or cuckow pint.

ARUNDELIAN MARBLES, are ancient stones, on which is inscribed a chronicle of Athens, engraved in Paros 264 years before Christ; and they take their present name from Thomas earl of Arundel, who procured them from the East, and made a present of them to the University of Oxford. This chronicle begins 1582 years before Christ; but it is so defaced, that the sense is discovered chiefly by conjectures. But in a dissertation, entitled, "The Parian Chronicle," the authenticity of these marbles has been questioned: 1st. Their characters have no certain or unequivocal marks of antiquity; 2d. it is not probable, that the chronicle was graven for private use; 3d. nor by public authority; 4th. it is not once mentioned by any writers of antiquity; 5th. some of the facts in the chronicle seem to have been taken from the writers of a later date; 6th. Parachronisms appear in some of the epochas; 7th. the history of their discovery is obscure and unsatisfactory. These marbles had been totally unknown or unnoticed for almost 1200 years, and at last are dug out of the ground—nobody can tell us when, or where!

ASBESTOS, a native fossil stone, which may be split into threads and filaments from one to ten inches in length, very fine, brittle, yet somewhat flexible, silky, and of a grayish colour. Asbestos is insoluble in water, and possesses the wonderful property of being incombustible.

ASCENDING STARS, are such as are rising above the horizon of any given parallel of the equator.

ASCENDING *Node*, ☊, that point of a planet's orbit where it passes the ecliptic, to proceed northward.

ASCENSION, *Right*, of any of the heavenly bodies, is that degree of the equinoctial counted from the beginning of Aries, which rises with the sun or star in a right sphere. *Oblique Ascension*, an arc of the equator, intercepted between the first point of Aries and that point of the equator which rises together with a star in an oblique sphere; and the ascensional difference is the difference between the right and oblique ascension.

ASCITES, dropsy of the abdomen.

ASCLEPIAS, swallow-wort.

ASCYRUM, Peter's wort.

ASHES, the earthy particles of combustible substances after they have been burned; those of vegetable bodies possessing a fixed salt, as potash, pearlash. Ashes are an excellent manure for cold and wet grounds. In their religious ceremonies, the Jews sat on ashes, threw ashes on their heads, and fed on ashes, which, however, is a poetical allusion. There was, nevertheless, a lustral water made with the ashes of a sacrificed heifer, which was distributed to the people, and used in purifications as often as they touched a dead body, or were present at funerals. Numb. xix. 17. 2 Sam. xiii. 9. and Ps. cii. 9.

ASIA, extends about 6500 geographical miles east and west, reckoning from the Hellespont to what is called East Cape; and about 4500 geographical miles, north and south, from Cape Cevero Vostochnoi, on the Arctic ocean, to the southern cape of Malacca. And it contains the following states:—*In the North.* The countries of Siberia, or Russian Tartary; whose chief towns are, Astracan, on the Wolga, Tobolsk, on the Irtish. *In the Middle.* Countries: the Chinese empire, Chinese Tartary, Tibet, Independent Tartary, Turkey in Asia. Chief towns: Pekin, Cashgar, Lassa, Samarcand, on the Sogda, Aleppo, and Jerusalem. *In the South.* Countries; Arabia, Persia, Hindostan, the Birman empire, Malaya, or Malacca. Chief towns: Mecca and Medina, Ispahan and Shiraz, Delhi and Calcutta, Ummerapoora and Ava, Malacca. The religions of Asia are very various: in Turkey the Mahommedan and Christian both prevail; in Asiatic Russia are found the two former, and also a species of Hindooism; the Chinese believe in polytheism; in Tibet, the religion bears a close affinity to that of the Hindoos: in Japan, polytheism obtains; the Birmans are worshippers of Brahma, as are also the Siamese, and the Hindostanese; the religion of Persia is the Mahommedan, as is also that of Arabia, while in the Asiatic islands several of the foregoing faiths have their respective devotees; and there are some insulated savages without any vestige of religious rites. The oceans, seas, bays, and gulfs, belonging to Asia, are: the Arctic, Pacific, and the Indian oceans; the Arabian Gulf, or Red Sea, between Africa and Arabia; the Persian Gulf, between Arabia and Persia, receiving the Euphrates and the Tigris; the Bay of Bengal, separating the peninsulas of India; the Gulfs of Siam and Tonquin; the Yellow Sea, the sea of Japan, and that of Okhotsk. Adjacent to Europe, Asia claims a share in the Levant, the Archipelago, the sea of Marmora, the Black Sea, and the sea of Azof. The Caspian Sea is an inland lake, 700 miles long, and from 200 to 700 broad. The sea of Aral is 200 miles long, and 70 broad; and that of Baikal is 850 miles in length, but only 35 in breadth. The chief Asiatic straits are those of Babelmandel, Malacca, Sunda, Corea, and Bherrings, between Asia and America. The mountains are, the Ouralian chain, forming the boundary between Europe and Asia; the Altaian chain, extending 6000 miles across the centre of Asia; the mountains of Tibet, the highest on the globe, being in one place above 26,000 feet above the level of the sea; Mount Taurus; the Caucasian chain, Mount-Ararat, Lebanon, and the Gauts of Hindostan. The chief rivers are the Obe, the Enissei, the Lena, the Amour, the Hoan-ho, the Kian-ku, the Maykaung, the Maygne, the Trawadely, the Burrampoot, the Ganges, the Indus, the Godavery, the Kistna, the Euphrates, the Tigris, and the Wolga. The canals of China are very numerous, and facilitate commerce in all directions; while the magnitude of the Ganges, the Indus, and many other rivers, admits of an uninterrupted navigation for nearly 1000 miles, for vessels of 200 tons burden. The Asiatic islands are the Laccadive and Maldive islands, Ceylon, the Nicobar and Andaman isles; the Japanese islands, the Eastern Archipelago, Austral-Asia, and Polynesia.

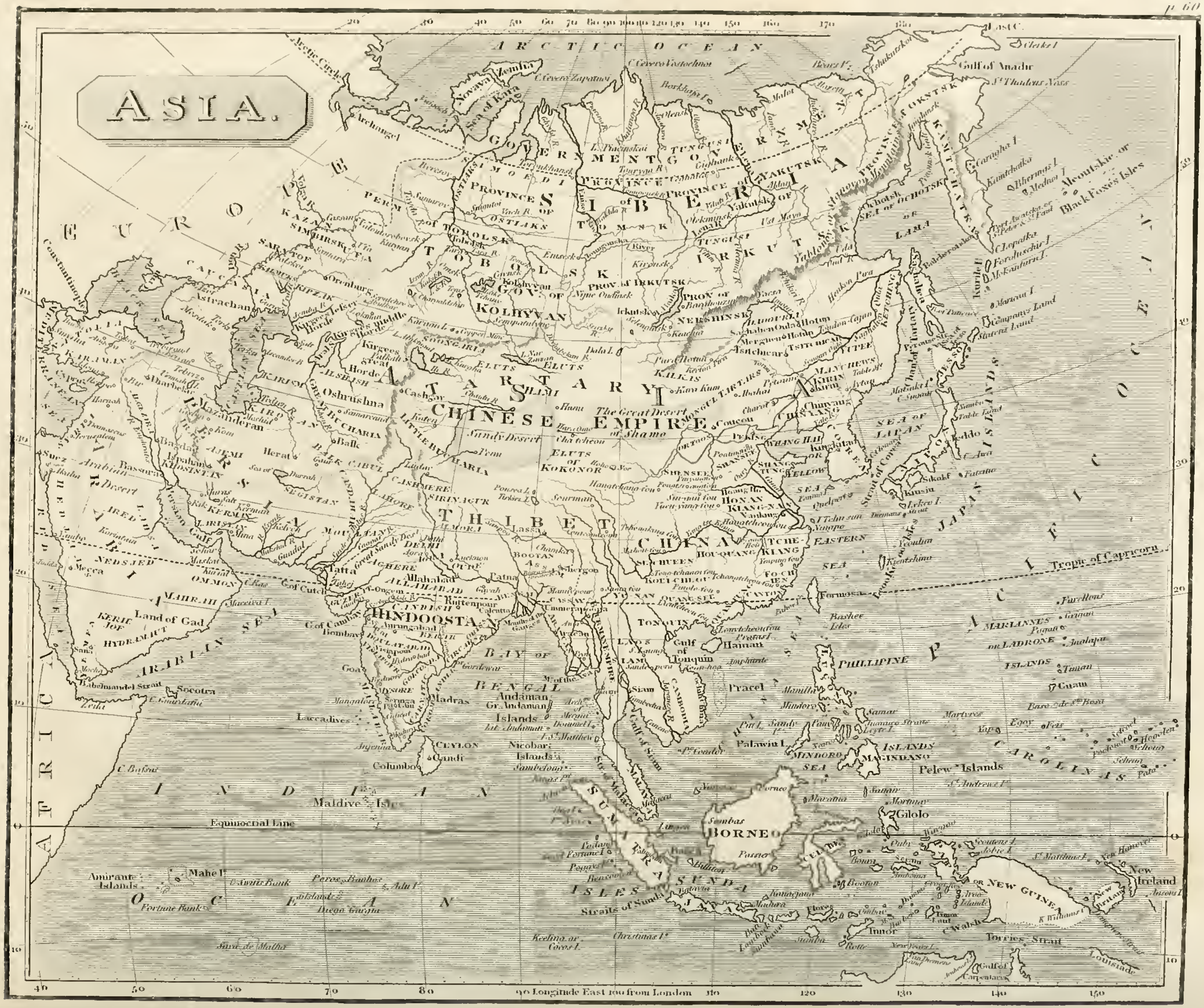
Turkey in Asia.—This region is divided into nine provinces, extending from the shores of the Archipelago, in Europe, to Persia; and these provinces are subdivided into governments arbitrarily ruled by pashas, or military commanders. The provinces are, Natolia, in the west; Karoman, in the south; and Roum, in the north-east; Guria, Mingrelia, Circassia, north of Armenia, or Turcomania, and south of it are Kurdistan and Irak-Arabi; Mesopotamia, and Syria. The population is estimated at ten millions, and of this mass of human beings, one half are pastoral wanderers, without industry, arts, or civilization. The chief cities are, Aleppo, with a population of 250,000 inhabitants; Damascus, containing 100,000 souls; Smyrna, 120,000; Prusa, 60,000; Angora, 80,000; Tokat, 60,000; Bassora 50,000; and Bagdat, 40,000. Aleppo is famous for its manufactures of silk and cotton; and its numerous mosques, surmounted with white minarets, and relieved in the distant landscape by the tall cypresses, give this elegant city a most picturesque appearance. Damascus for its swordblades is unrivalled; and its manufactures of silk, cotton, and soap, are very considerable. Smyrna is the chief mart of European trade on the shores of the Levant; but the pestilence retards its prosperity. The climate is most excellent; and though the soil be in general good, agriculture in Syria is in a most wretched condition. The chief rivers are the Euphrates, the Tigris, the Kizil-Irmak, or Halys of antiquity; the Meander; the Sarabat, or ancient Hermus; and the Orontes, in Syria. The lakes are, Van, in Kurdistan; the Dead Sea, in Syria; the Tata, or Palus Salsa, of Asia-Minor; Ulubad, in Natolia, and the Isnick. The mountains are, the Taurian Chain; the Caucasian mountains; Ararat, in the east of Armenia; Lebanon, in Syria; Olympus and Ida, on the east of the Archipelago. These mountains are clothed with immense forests of pine-trees, oaks, beeches, elms, and other alpine trees, which furnish safe retreats to tigers of the smaller breed, hyænas, wild boars, troops of jackals; and the ibex roves on the summit of the Caucasus; while Angora is celebrated for its singular goats and cats, from whose wool are manufactured Angora shawls, &c. The islands belonging to Asiatic Turkey are, Mytilene, Scio, Samos, Cos, and Rhodes. Mytilene is mountainous, but agreeably diversified with olive gardens, vineyards, and plantations of myrtle. The climate is exquisite; and the coast is finely indented with numerous creeks and havens. Scio, or Chios, contains about 60,000 inhabitants; and the Greeks make a decent livelihood in the cultivation of mastic gum, for the ladies of the sultan's harem. Samos, with a population of 12,000 Greeks, is famous for its pottery, its honey, and wax. Cos is covered with groves of lemon-trees. Rhodes, whose population is 30,000, was once celebrated for its colossal statue in bronze, and its having been possessed by the knights of St. John of Jerusalem. Cyprus is fertile, but agriculture is neglected. Its wines and oranges are excellent, and its hills are bedecked with the most beautiful flowers.

Russia in Asia.—The Russian empire extends along the whole of Asia. If we compute the degree of longitude in that high latitude at 30 miles, the length (reckoning from 37° east longitude, to 170° west longitude) will be about 4590 geographical miles; and its mean breadth cannot be less than 1960 miles, estimating from Cape Vostochnoi to the sea of Baikal. The ancient name of this vast empire was Siberia. The population of this extensive empire is almost all of primitive origin, consisting of Samoides, Monguls, Kalmucks, Tartars, &c. And they profess, according to their tribes, the Mahommedan religion, that of the Greek church, or the superstition of Dalai-Lama, &c. The government of Siberia is divided into two branches, that of Tobolsk in the west, and Irkutsk in the east; and the population does not exceed three millions and a half. The Tartars are generally hunters, or herdsmen, feeding horses, camels, oxen, sheep, and goats; and their women busy themselves in tanning leather, gardening, and providing winter provisions. The Kalmucks are divided into three classes, nobles, clergy, and people, and the power of their chief consists in the number and opulence of his subjects. The Monguls are of short stature, with a flat visage, small oblique eyes, thick lips, and short chin, from which depends a scanty beard. Their hair is black, and their complexion a yellowish brown. Like all pastoral tribes, they are docile, hospitable, and active, but voluptuous; and hence industry is a virtue entirely confined to the females. Wandering in herds in quest of sustenance for their flocks, with much mirth they amuse themselves in horse-racing, archery, wrestling, pantomime, dancing, cards, and chess. The chief cities are, Astracan, at the mouth of the Wolga; Azof, Tobolsk, Kolyvan, on the Ob; Irkutsk, the chief mart of commerce between China and Russia. The chief manufactures are, leather, salt, isinglass, kaviar, (the salted roe of a large fish,) and pitch; and the chief articles of commerce are sables, furs, hides, rhubarb, and raw silks, which are exported, or exchanged, for tea, silk, porcelain, wine, fruit, coffee, rice, woollen cloths, iron, and household goods. In so extensive a country the climate and soil are very various; though in general the former be frigid rather than temperate, the latter might be cultivated to great advantage in the southern and western districts, were the peasantry not sold as slaves with the ground they tread on. The chief rivers are, the Ob, navigable almost to its source, and abounding in fish; the Yenidei, issuing from the Baikal, or Holy Sea; the Selinga, flowing into the Baikal; the Lena, of great breadth, and full of islands; the Wolga, the Amur, and the Onon. The chief lakes are, those of Piazinsko, in the north; the Baikal, in the south; the lakes of Tchany and Soumi, between the Ob and Irtish; the Bagdo, to the north of the Caspian, is salt water, as is also the Altan-Nor, or Gold Lake. The mountains are, the Uralian chain; Bogdo-Alim, adjoining the Mongolian desert; the Altaian chain; the Schlanganberg, rich in minerals, as are also the mountains of Nenshinsk; the mountains of Ochotsk, many branches of which consist of red and green jasper; and the classical Caucasus, whose summits are crowned with everlasting ice and snow. Asiatic Russia abounds in forests and *stepps*, or extensive level plains, which resemble the sandy bed of a sea, with scattered patches of thin grass, stunted thickets, spots of salt, and saline lakes. In the forests, the terrible urus and the bear range; the argali, or wild sheep, and the ibex, or rock goat, inhabit the Caucasus; the rein deer performs the office of the horse; the mountains of Baikal abound in large stags; and the white foxes of the Eastern Archipelago rival the monkey in mischievous tricks. The isles belonging to Asiatic Russia are, the Aleutian isles on the east of Kamschatka, the Andrenovian or Fox islands on the west of the former; and the Kurilian isles, extending from the south of Kamschatka to Japan. Several of these isles are volcanic; and they all swarm with foxes.

The Chinese Empire.—This vast empire extends in an easterly direction 4200 geographical miles, and southerly 1740 miles. By glancing at the map of Asia, we perceive it stretching from the Pacific Ocean to the river Sihon, and from the Uralian mountains to the tropic of Cancer. It is divided into three parts, China Proper, the kingdom of the Mandshurs and Monguls, on the north and west, and the territory of Tibet.

I. China Proper.—China Proper (extending from the great wall in the north to the Chinese sea in the south) is 1140 geographical miles long; and in breadth (from the shores of the Pacific to the frontiers of Tibet) it is computed at 880 geographical miles. The religion is polytheism. The government patriarchal: hence the amazing population and general ease and happiness of the people. The population amounts to three hundred and thirty-three millions of souls, the army is one million, and the revenue amounts to nine millions sterling.

p 60



Published by Fisher, Son & Co. Caxton, London 1825.

The features of the Chinese proclaim their affinity with the Tartars, Monguls, and Mandshurs; and though they appear highly civilized, science is still in its infancy among them, and must ever be so, where, from age to age, genius is cramped by the children following the business of their fathers. The chief cities are Pekin and Nankin; the former possessing a population of three millions of souls, and the latter is yet more extensive. In Canton there are a million and a half of inhabitants. The characters of the Chinese people in the different provinces are thus portrayed in the last court calendar of the celestial empire.—1. Peking, or Shun-teen-foo. The people are strong and brave; silent, famous for politeness and justice; plain, unceremonious, and moral, regenerated by their vicinity to the emperor.—Paou-ting-foo. Literati not endowed with remarkable talents, and agricultural people.—Yung-ping-foo. The literati value their reputation; a frugal people, attentive to agriculture.—Tee-tsin-foo. A mixed people from every part of the country; gay and extravagant, some frugal.—2. Keang-see—Keang-nin-foo. An extravagant people, a great number of literati.—Soo-chow. The scholars are very polite, and the people taught to love each other. Their manners are pure, and instruction has a powerful effect.—Sung-keang-foo. The literati are studious, the people eminent for benevolence.—3. Gan-hwuy. A light unsteady people; economical, and of good appearance.—4. Keang-se. The literati are partial to classical learning, the people attentive to husbandry.—5. Che-keang.—Hang-chow-foo. Gems and rarities are here collected. Foreign and home trade are united. The people are genteel and elegant. The literati are very methodical.—6. Fo-këen, Fo-chow-foo. Inwardly sincere, and of a gay exterior; very attentive to business, and value economy.—7. Hoo-pee, Woo-chang-foo. A mixture from every part of the empire. Every family observes its own customs. The Chinese roads are excellent, and no country excels this in inland navigation. Irrigation is very well practised, husbandry is neat and clean, and the emperor himself is not ashamed to hold the plough in its season, and sets an annual example of the veneration due to the chief branch of human industry. The lakes are noble and extensive, and afford vast quantities of fish, which are taken by trained birds. The rivers are the Kian-ku and the Hoan-ho. The mountains, though numerous, have not yet been accurately described; and except in the loftiest districts, cultivation has annihilated all the great forests. Yet tigers, buffaloes, wild boars, bears, rhinoceroses, camels, and deer, find ample shelter. The common people pound their coal with water, and bake it in cakes for use. The Chinese islands are Formosa, Hainan, and the isles of Leoo-keoo, between Formosa and Japan. Their inhabitants form a civilized kingdom, subject to China, and their manners appear mild, affable, gay, and temperate.

II. Chinese Tartary.—Chinese Tartary, or Mongolia, extends over the vast regions between Tibet, China, and the Arctic Ocean; and from the Black Sea to the north-eastern boundaries of Asia. That is to say, from 72° to 145° east longitude, or seventy-three degrees, equal to 3100 geographical miles, taking the medial latitude at 45°; and from the Russian confines to Tibet, its breadth of 18° will give 1,080 geographical miles. The religion is called Shumanism, or the belief in a Supreme Author of nature, who governs the universe by the agency of numerous inferior spirits; but a living Lama, or embodied spirit, is acknowledged and worshipped; and this Lama is a human being like ourselves! The princes pay homage to the Chinese empire; the population amounts to about six millions of souls; and the whole country is divided by the Chinese into the three great governments of Chinyang, Kiren-oula, and Tsitchicar; while the territory of the Oelets or Kalmucks comprises Gete, Little Bucharia, and the countries of Turfan. The chief towns are, Cashgar, Yarkand, and Kotan, in Little Bucharia; Turfan, Hami, Chami; Coucou, Hotun, Tsitchikar, Merguen, Petouna, Kirin, and Nigouta. The chief city of Corea is Kinkatao. The chief trade of these places lies in pearls, horses, musk, and furs. Corea is celebrated for the most exquisite horses, only three feet high. A mare of this breed was exhibited in London, in 1820. The climate, in general, is as mild as that of France and Spain, and the great Table Plain, extending from 80° to 110° east longitude, or 1380 geographical miles, is the most singular feature in the face of the country. In all Chinese Tartary the predominating substance of soil is black sand, and agriculture is wholly neglected. The chief rivers are, the Amur or Sagalian-Oula; the Yarkand, and the Ili; the former falling into the lake of Lop, the latter into that of Balkash or Tengis. The mountains are, the Imauau chain, or the Dark Mountains of Belur Tag; those of the Russian frontier, and the mountains of Tibet. The island of Sagalian, or Tchoka, 240 miles north of Jesso, is mountainous towards the centre, but the shores are adapted to agriculture; and the natives dress in loose robes of skin, and live in huts, a mild and intelligent race, unlike the Manshurs.

III. Tibet.—Tibet is about 1350 geographical miles long, and 480 broad, extending from the 75th to the 101st degree of east longitude; and from the 27th to the 35th degree of north latitude. It is divided into Upper, Middle, and Lower Tibet; the first comprising the province of Nagair, full of stupendous rocks, covered with eternal snow; the central region, embracing the provinces of Shang, Ou, and Kiang; while Lower Tibet includes the provinces of Takbo, Congbo, and Kahang. The religion of the Tibetians is closely allied with the Hindoo faith; but differs essentially in its ceremonies. For instance, the Tibetians assemble in temples, chant in alternate recitative and chorus, accompanied by instruments of music; and they have numerous monasteries, inhabited by hosts of *gylongs* or monks, and *annees* or nuns. In a word, they resemble the Catholics. The ruling government is spiritual, but a secular regent manages the affairs of the half million of people who inhabit Tibet. The revenue of the Lama, or pope, and of the secular princes, is trifling. And it is a remarkable fact, that, in regard to polygamy here, the women indulge themselves with pluralities of husbands. The chief city is Lassa, seven miles east of which is the palace of the Lama, or pope. Bridges of chain are common, passing from precipice to precipice. And though there is a great want of industry, the shawls of Cashmir are manufactured from the goats' hair of Tibet. The climate of Bootan is temperate, compared with that of Tibet Proper, whose distinguishing characteristics are extreme aridity and parching cold. And though Bootan be covered with eternal verdure, Tibet Proper presents a peculiarly naked aspect, indicative of rich ores. Its abundance and variety of wild fowl and game, its flocks of sheep and goats, and herds of cattle, have been noticed by all travellers, in all times. The chief river is the Sampoo or Burrampooter, but many of the Asiatic rivers have their sources in Tibet, whose mountains are the Alps of Asia.

Japan.—Japan consists of several islands, extending from the 30th to the 41st degree of north latitude, and from the 131st to the 142d degree of east longitude. The chief of these islands are Nipon and Jesso; but the whole are divided into provinces and districts, with as much method as the most civilized countries of Europe. The established religion is polytheism; the people abstain from animal food, and detest bloodshed; and viewing the gods as beings dispensing happiness, they solemnize their festivals and modes of worship with cheerfulness and even gaiety; nor are they without monks and nuns of different orders, as in Tibet. The government is monarchical, and each province is ruled by a resident prince, who, in pledge of his good administration, is obliged to leave his family as hostages at the emperor's court. And the laws being few, but rigidly enforced, without regard to persons, partiality, or violence, are posted up in every town and village. The population amounts to thirty millions of souls, and the army to 500,000 horse and foot. The revenue has been reckoned thirty millions. This highly civilized people use no wine or spirituous liquors, though their food be various and their sauces numerous. Their dress consists of trowsers and loose gowns or robes of silk, worn alike by both sexes; and in their games and theatrical amusements the Japanese rival the Europeans. In varnishing they have no equals, and in some of their arts and manufactures they excel even the British, the Germans, and the Chinese. The chief town, Jedo, is on the south-east side of Nipon, and Miaco, the spiritual capital, is the second city in the empire. The Dairi, or pope, resides here, and here also all books are printed from stereotype blocks. Japan is exposed to a copious moisture, from the rains which fall from midsummer to autumn, and the fertility of the country may be attributed to this cause; tempests, hurricanes, and earthquakes, are common. Agriculture is highly esteemed and sedulously cultivated, even on the mountains and hills; and the farmer labours under no restraint from taxes and tithes. Rice is the chief grain; but potatoes, beans, pease, turnips, and cabbages, abound. And the varnish and camphor trees, the vine and the cedar, and the tea-tree, are cultivated. Among the rivers and lakes described by geographers and travellers, we may enumerate the Nogafa, the Jedogawa, the Ojingawa, and the Jodo, as celebrated rivers; and one of the chief lakes seems to be that of Oitz. The mountains are numerous, and intermixed with many sublime volcanoes, and the delightful sacred mountain of Jesan is decorated with no fewer than 3000 temples. Among the islands dependent on Japan, is Fatfifo, the place of exile for disgraced grandees, and political offenders, who are spared capital punishment, to endure the more severe chastisement of perpetual banishment.

The Birman Empire.—The Birman Empire includes the space between the 9th and 26th degrees of north latitude, and between the 92d and 107th degrees of longitude east of Greenwich; about 1020 geographical miles in length, and 900 in breadth. The population amounts to seventeen millions; the government is despotic; and a nobleman is distinguished by the number of chains, three, six, nine, or twelve, around his neck. The religion is that of Brahma, belief in the transmigration of souls, and eternal happiness in Mount-Meru. Their navy resembles the Roman galleys; and their army is inconsiderable, though every male is liable to military service. The Birmans are lively, irascible, and impatient; their women are laborious; hence infidelity, the offspring of idleness, is rarely known among them. The great alone are educated, the poor are totally neglected. The chief cities are, Ava, the ancient capital; Ummerapoora, the new capital, resembles Venice in its spires, turrets, and obelisks. It is built on the eastern side of a great river that flows into the Irrawady, amidst numerous islets. Pegu is known chiefly by the temples which Alompra spared when he razed the city in 1757. The Shomadon, an extraordinary building of Pegu, is 361 feet high, surmounted by the sacred umbrella, fifty-six feet in circumference, and said to have been erected 500 years before Christ. Rangoon, the chief sea-port, contains 30,000 souls; Prome is celebrated as the scene of many sieges; and Aracan, Quantong, Bamoo, Munnipora, and Monchaboo, are considerable places. The inland navigation is most ample, from the numerous rivers and streams. The Birmans excel in gilding, and in carving marble divinities. The seasons are regular, the climate salubrious, and the people vigorous and healthful. The chief rivers are, the Irrawady, which joins the sea by many mouths; the Keen-Duem, the Sitang, and the Thaluan. And the mountains are those on the frontiers of Tibet, the range of Anoupec, between Ava and Aracan. The forests are large and numerous, and covered with everlasting verdure. The teak-tree flourishes as lord of the wood, in majesty of form and amplitude of growth. While in comparison of the Birman, our forests sink into vegetables of an inferior order, their shrubs and plants in their blossoms and fruits, by their brilliant colours and aromatic fragrance, reduce to relative insignificance the boasted produce of Italian summers.

Aracan.—In Aracan, the climate is pure, the plains fertile, and the valleys present numerous flocks of cattle; but the natives are averse to commerce and a maritime life. The Aracans will eat rats, mice, and serpents; and fish, to provoke the palate, must be out of season. The monarch lives in solitude and luxury with his queen and harem, which he thinks enriched by a concubine from Jangoma, a small kingdom in the vicinity of the Birman empire, and on the north of Siam. But the women of Jangoma are famed in all the east for their gallantry and beauty. The temples resemble pyramids, and there are three orders of priests, living in perpetual celibacy.

Malaya, or Malacca.—Malaya is an extensive peninsula appended to the Birman territories, and divided into the kingdom of Patani in the north, and that of Johor in the south; the chief towns being Batusabar, the capital, Linga, Bintam, and Carimon. Malacca is 560 miles long and 150 broad; the inhabitants are indolent to agricultural pursuits, but restless for war, plunder, emigrations, and affairs of gallantry; and the Malayan history is full of desperate enterprises, that sufficiently characterize the ferocity of these Mahommedan barbarians. The peninsula of Malaya abounds in forests, stocked with abundance of wild elephants, whose teeth become a considerable article in the commerce of the natives with the Dutch and Portuguese. Opposite Malacca are the islands of Andaman and Nicobar, whose inhabitants are the most savage in the world; but they may profit by the example of British industry, as a colony has been formed on the greater Andaman for convicts from Bengal.

Siam.—Siam, 700 miles long, and 70 miles in medial breadth, is a rich and flourishing kingdom. The religion resembles that of the Hindoos; the government is despotic; the laws severe; the people amount to eight millions; the army 60,000, with 4000 elephants; the navy is numerous, though the vessels are mere galleys; and there is a royal treasury, but its revenue is unknown to Europeans. The whole country is a wide vale between two ridges of hills, and would be a terrestrial paradise, were it not subject to an absurd despotism, that cramps industry, and would annihilate agriculture, did not vegetation thrive in spite of the worst of governments. The Siamese are small of stature, but well made; and their feeding on rats, mice, lizards, and several kinds of insects which we loathe, but ill accords with their religion, and the products of a country which exports prodigious quantities of grain. In all works of industry the women are employed, while the men pass away their time at theatrical amusements, races of oxen, combats of elephants, cock-fighting, tumbling, wrestling, rope-dancing, and exhibitions of fireworks.

Laos, Cambodia, Siampa, Cochin-China, Tunquin.—Laos, though surrounded by forests and deserts, is fertile in rice, and furnishes the merchants of Cambodia with excellent benzoin and lacca, musk and rubies, gold and pearls; and the people, in their religion and manners, resemble the Siamese. Cambodia is thinly peopled; the capital, Cambaja, is a mere village of one street, with a single temple; and though the country is fertile in rice and animal food, and abounds in ivory and precious woods, the most peculiar product is gamboge gum, well known to artists for its fine yellow colour. Siampa is a small maritime country, south-east of Cambodia, and its prince is tributary to Cochin-China. Cochin-China presents an extensive range of sea-coast, and is divided into distinct provinces. Both sexes dress alike, in loose robes, with large long sleeves, cotton tunics and trowsers, with a turban on the head, but they walk barefooted; yet the Chinese display not more politeness than the Cochinians. Tunquin, divided from Cochin-China by a small river, resembles, in its people, territory, and products, the Chinese empire. In the gulf of Tunquin, *tuffons* are frequent and tremendous. They are preceded by very fine weather, a presaging cloud appears in the north-east, black near the horizon, edged with copper colour on the upper part, fading into a glaring white. It often exhibits a ghastly appearance twelve hours before it bursts; its rage lasts many hours from the north-east, attended with dreadful claps of thunder, large and frequent flashes of lightning, and excessive hard rains, when it sinks into a dead calm; after which, it begins again with redoubled rage from the south-west, and continues an equal length of time.

Hindostan.—Hindostan extends from about the 8th to the 35th degree of north latitude, or 1620 geographical miles; and from the 66th to the 92d degree of east longitude, or 1400 geographical miles. The population of this extensive portion of Asia is computed at 60,000,000; and the religion is polytheism; for the doctrine of the Bramins, or priests, teaches belief in a supreme Creator, too ineffable and sublime for human adoration, which is, therefore, addressed to inferior, but great and powerful divinities. This superstition inculcates four casts or orders of the people: 1. The bramin (priest) from the mouth (wisdom) of Brahma, (the supreme;) hence, the priests are supreme:—2. The chehteree, from the arms, (strength;) to draw the bow, to fight, to govern: hence, governors, soldiers, &c. a middle class:—3. The brice, from the belly and thighs (nourishment;) to provide the necessaries of life by agriculture and traffic: hence farmers, merchants, &c.—4. The snoder, from the feet, (subjection;) to labour, to serve: hence, the slaves, or day-labourers, &c. The

Hindoos believe in the transmigration of the soul, and therefore abstain from animal food, yet no where on earth are fanatical penances, suicides, and superstitious frenzies, so common. They excel in the manufacture of cotton goods, of metals and ivory, and shawls of Cashmir. The loom in which cotton cloths, or shawls, are woven, is a moveable frame, reared with the rising sun, beneath some shady trees, and transported to its owner's dwelling when the shades of night begin to leave the warp and the woof alike undistinguishable to the craftsmen. The native products are rice, sugar, spices, aromatics, drugs, and precious stones. The climate is diversified by local situation, as is also the aspect of this wide and extensive country; but the periodical rains and intense heats produce luxuriance of vegetation elsewhere unknown, and none can be an indifferent spectator of the variety and richness of the vegetable kingdom of Hindostan. But then the soil is in many places a black mould four feet deep. The chief rivers are the Ganges and the Indus, the Burrampooter, the Sindé, and the Kistna, or sacred stream. The lakes are few, and consist chiefly of Colair, twelve miles north of Masulipatam; Chilka, a salt creek, communicating with the sea, as is also Pulicat; and Cashmir, supposed originally to have been a large lake, still boasts the Oullar, or Tall, fifty-three miles in circuit. The chief mountains are, the southern Tibetian Alps, shrouded in eternal snow, and hence called the Himmala; and the Gauts of Hindostan. Few maps can be relied on respecting the mountains of Hindostan; for in many instances the most recent are copied from the antiquated conjectures of D'Anville. The forests of Hindostan are large and exuberant of vegetation; but the loftiest tree is the palm. The cocoanut tree the most widely diffused; the cotton-tree, the banyan, the teak-tree, and the tamarind, with a numerous botanical collection, which we forbear to mention. The countries on the Ganges are the provinces of Bengal, Bahar, Allahabad, Oude, Agra, with part of Delhi and Agimere, and of Malwa in the south, once the chosen seats of the Mogul power. Bengal, Bahar, with Benares, and some other districts to the west, are in the possession of the British. This extent of territory is not very exactly defined, and the population is, perhaps, not accurately estimated at 11,000,000 of black subjects. The clear revenue has been given at one million and a half; yet the East India Company has not been able to go on without parliamentary interference; and government has a Board of Control to watch over the Company's proceedings. The government of Bengal is vested in a governor-general, who controls also the inferior governments of Madras on the east, and Bombay on the west, with Bencoolen in the island of Sumatra. The British army, supported by the native infantry and cavalry, is now numerous; though the battle of Plassey, which established us in India, in 1757, was won by the invincible army of 900 Europeans; or in the ratio of 1 British soldier to 11½ Hindoos. The chief cities are, Calcutta, the grand capital of British Asia; Patna, the capital of Bahar, 400 miles north-west of Calcutta; Benares, on the northern bank of the Ganges, and 460 miles from Calcutta; Allahabad is the ancient, and Lucknou the present, capital of Oude; Agra, Delhi, and Agimere. The countries on the river Sindeh, or Indus, are part of the provinces of Delhi and Agimere, the provinces of Moultan, Lahore, Cashmir, Cabul, Candabar, and Sindi, at the mouth of the Indus. The chief cities are, Lahore, Cashmir, Cabul, Ghisni, Candahar, Moultan, and Tatta. Lahore is the capital of the Seiks, a new religious sect. Cashmir is a filthy place, though the adjacent country is a delicious vale. The central division of Hindostan comprehends the province of Orissa, with part of Golconda, Berar, Dowlahabad, Candeish, Guzerat, and some other districts of inferior note. The Sircars, British provinces, skirt the eastern shore. The chief towns are, Amedabed, the capital of Guzerat, and Cambay, its sea-port; Surat, whose inhabitants are chiefly Moors, Persians, Monguls, and Turks; Bombay, situated on a small but well fortified island, with the isles of Salfatte, and Elephanta; Burhampour, Nagpour, Poona, Masulipatam, and Aurungabad, once the capital of the Deccan. The southern division of Hindostan is called the Deccan, extending from the latitude of Bombay, or 18½ degrees north, to the southern point of Cape Comorin. This part of India nearly contains the whole province of Visiapour, part of Golconda, the central kingdom of Mysore, the long eastern province of Carnada, or the Carnatic, the principalities of Tanjore, Travancore, and the Samorins of Calicut, the pepper-coast of Canara, and other districts of minor note, with the island of Ceylon. In the Deccan the British power and influence are amazingly extensive; for, besides Madras, and its adjacent territory, the possessions of the East India Company in the south of Hindostan, yield only in extent to those of the north on the Ganges. The chief cities are, Seringapatam, Salem, and Attore, in the east; Dindigul, Coimbetore, and Palicaud, on the south; Paniany, Ferokabad, and Calicut, on the western side; and on the north, Tellicherri, Mangalore, and Carwar. Arcot is the capital of the Carnatic, or of Carnada. Tranquebar is a Danish settlement in Tanjore; Pondicherri was originally a French settlement. Vasco de Gama died at Cochin, on the Malabar coast, in 1525; and Goa is the noted seat of the horrible inquisition. Ceylon is about the size of Ireland, or 260 by 150 miles; and is important chiefly in a commercial view, from its celebrated cinnamon and gums. The religion is the ancient worship of Boodh. The population is not numerous, and the Ceylonese allow to the women a polygamy of the males, as in Tibet. The principal towns are, Kandi in the heart of the island, Colombo, and Trincomali, celebrated chiefly for its harbour. The air is cool and salubrious, and the mountainous districts, in the centre of the island, are covered with prodigious forests, stocked with aromatic trees, and the most odoriferous plants. The soil of the vales is rich, fertile in rice and useful vegetables; and numerous pleasant rivers, and delightful streams, diversify this isolated paradise, swarming with peacocks and other elegant birds. The Mahommedans believe Ceylon to have been the residence of Adam. The Laccadive and Maldive isles are near the coast of Hindostan. The latter, more than 1300 in number, are governed by a chief, called Atoll, and produce cowrie-shells, cocoa-nuts, and fish; the former, thirty in number, trade in cocoa-nuts, fish, and ambergris.

Persia.—Persia may be considered as divided into the eastern and western empires, and the independent provinces, near the Caspian sea. From east to west its length is about 1200 miles, and 1000 broad from north to south. The population is about 10,000,000, of which 6,000,000 are assigned to the western, and 4,000,000 to the eastern empire. The religion is the Mahommedan, but there are still some Parsees, or worshippers of fire, near Baku, and at a place called Gusberabad, near Ispahan. The government is despotic, but its administration in Pandehar, the eastern empire, is extremely mild. The revenue is estimated at 3,000,000*l.* sterling. The provinces are, Georgia, Erivan, Aderbijan, Ghilan, Mazendran, Irac-Ajemi, Chosistan, Fars, or Persia Proper, Kerman, Laristan, Mekran, Segistan, Corasan; Balk and Great Bucharia belong rather to Independent Tartary. Persia is destitute of a navy, though enjoying a great extent of sea-coast; and the maritime commerce is chiefly in the hands of foreigners, because the natives love rather to attend to their studs of horses, and the diversions of the chase, than to improve their own property, or to promote the prosperity of their country. The Persians are polite, hospitable, wise, and sagacious; the men strong and robust, remarkable for cleanliness, but subject to disorders of the eyes. The women are very beautiful; and amidst their abject superstitions we notice chiefly astrology, that proud sophistry, which links the momentary existence of man with the eternal laws of far distant suns and worlds. The chief cities are, Ispahan, the capital; Huraz, celebrated for its delicious climate, and the exquisite salubrity of its atmosphere, perfumed by numerous fragrant flowers, and filled with the divine notes of the bulbul, or oriental nightingale. Tiflis, the capital of Georgia, is famous for its hot springs, and trade in furs; Derbent, on the Caspian sea, is productive of excellent grapes; Erivan, the capital of Persian Armenia, is not far from Mount-Ararat; Tauriz, in Aderbijan, is noted for its bazaars; and Rasht and Sari are the capitals of the Caspian provinces, Ghilan and Mazendran. Persia is famed for its carpets, its embroidery, porcelain, leather, sabres, silk, and bows, the trustiest in all the east. The climate is diversified, but excellent for the human constitution. The most singular feature in the face of the country, is its grand division into two parts, by mountains and deserts; and hence, though the northern provinces are rich and fertile, those of the south, and even the centre, are unfertile, without extreme care to irrigation. The chief rivers are, the Euphrates and the Tigris, the Divrud and the Gihon, the Zeuderud, which passes by Ispahan, and the Bundamir, between Shirez and Iskakar. The principal lakes are those of Zeré, or Durra, in Segistan; the salt lake of Baktegan, fifty miles east of Shirez, lakes Urmia and Erivan. And the mountains most deserving of notice are, the Caucasus, to the west of Ghilau, and the south of Mazendran; the Persian Gulf chain; the grandest range is south of lake Urmia, where it is joined to the Caucasus; Mount-Ararat; Hetzardara, or the thousand mountains. The forests of Persia abound with deer, bears, boars, lions, tigers, and antelopes; the mountains with wild goats; the numerous wastes swarm with hares, wild asses, and hyænas; and the flocks of large-tailed sheep augment in Erivan. The partridges are large and plentiful, and the pigeons excellent. Among the natural curiosities of Persia, the most remarkable is the inflammable naphtha, or pure rock-oil, found in the neighbourhood of Baku, on the western coast of the Caspian sea. Ormus is the most noted of the Persian isles, though it be now abandoned; and famous chiefly for its salt, which is collected on the rocks, from the spray of the sea, in a fit state for the table. Gombroon, or Kishma, and Karek, are ports of some importance in the Persian Gulf.

Independent Tartary.—This singular region extends from the Caspian sea to the mountains of Belur, or 870 miles east and west; and from the mountains of Gaur in the south, to the Russian boundaries, on the north of the desert of Issim, or about 1500 miles. The chief divisions are, the barren plains in the north, inhabited by the several hordes of Kirguses, called anciently Turkistan; Ilak and Shash, the most northern provinces on the Sihon, are on the south of the Argun mountains; Fregana and Orushna, with the kingdom of Kharizm; south of the Ak-Tau, or white mountains, are the fertile provinces of Sogd, Balk, Kilau, Tokarestan, and Gaur. The chief towns are, Cashgar and Yarcaud, Axu and Yulduz, or Karashar, (the black city;) Turfan, and Hami, or Camil. The prevailing religion is the Mahommedan. The inhabitants are polite and benevolent Kirguses, about half a million of souls, Bucharians and Kalmuck Tartars, expert in the lance, the sabre, and the bow. The desert of Issim divides the Kirguses from Siberia; and the three great hordes of these people live in tents, leading a wandering life, regarding each other as brethren, rearing vast herds of cattle and horses, and delighting in the chase of wolves, foxes, badgers, antelopes, wild asses, chamois, and tigers. The Kirgusians trade with Russia, supplying annually 150,000 sheep, vast troops of horses, and abundance of wool; and in exchange they receive clothes and furniture, and from Bucharia arms and coats of mail.—Khanrizm, a province of independent Tartary, extends from the Gihor to the Caspian sea, about 350 miles long, by as many broad; its chief town is Khiva. Khiva is seventeen days' journey from the Caspian sea, and thirty-three from Orenburg. The coasts of the Caspian are held by Turkomans in the north, and Uzbeks in the south.—Great Bucharia, the most important part of Independent Tartary, extends 700 miles in length from north to south, and 350 miles in breadth from east to west. The mountains of Argun bound it on the north, the river Armu on the west, and on the south and east, the mountains of Gaur and Belur. The religion is the Mahommedan; the government is despotic; and the Uzbeks and Bucharians are the most spirited and industrious, amidst surrounding barbarians. But the Bucharians never bear arms, though the women of the Uzbecks, surpassing those of the other Tartars in beauty, fail not to follow their lords to the field of battle. The provinces of Great Bucharia are, Fergana, Andegan, Sogd, Kottan and Kilan, Tokarestan, and Gaur. And the chief cities are, Samarkand, Bokhara, Balk, Zouf, or Gaur, Badakshan, and Kotlan. Samarkand was famous for its manufacture of silk paper, as early as A.D. 650; Bokhara, for its fine linen, was distinguished even in the tenth century; Balk, for its beautiful silks; Gaur, for its rich quarries of lapis lazuli; and Badakshan, included in the Belur-Alps, was used as a state-prison, for rivals, or insurgents, against the khan of Great Bucharia. Situated in the parallel of Spain and Greece, the climate of Bucharia is excellent. The soil adjacent to the rivers is fertile, but neglected. The chief rivers are, the Armu, and Sirr, or Shash; the island seas are the seas of Aral and Baikal, and the lakes are those of Tengis and Balkash; and the chief mountains are those of Belur, of Gaur, the Hindoo-Koh, of Argun, of Kara-Tau, and Ak-Tau. Ebu Haukal says, all the families of Independent Tartary are but one house; and, in Sogd, he saw a great building, whose doors were fastened back with nails against the walls, continuing thus open night and day, for above 100 years, that strangers, who should arrive at the most unseasonable hours, might find no obstacle to enter, and receive every thing necessary both for man and beast.

Arabia.—Arabia, bounded by the Red Sea, the Indian Ocean, and the Persian Gulf, on the west, south, and east, and on the north by the Mediterranean and Palestine, is about 1800 miles from north to south, and 800 broad. The centre of Arabia is a vast desert. The provinces situated on the sea-coast are fertile in millet, barley, beans, lentils, rape, sugar-cane, tobacco, cotton, valuable spices, pomegranates, melons, and coffee. The religion is the Mahommedan, but a new sect, called Wahabees, has made considerable progress. This sect has derived its name from one Abdul Waheb, a sheik, or imam, in the province of El-Ared. A sheik (old man) is a governor of a province, and an imam (vicar) is an ecclesiastical ruler, as the twelve imams, the genuine successors of Mahomet, in Persia. In Arabia, an imam is a calif, or prince of the faithful. The Arabians are polite and hospitable, temperate in eating, and abstemious of wine. The women dye their nails of a scarlet colour, their feet and hands of a yellowish brown, and no art is left unemployed to make the eye-brows large and black. Many of the poorest people read and write, as education is attended to very generally, and the chief cities are celebrated for colleges and academies. The holy cities are Mecca and Medina. Gedda, a sea-port, forty miles distant from Mecca, was famous in ancient times, when the markets of Saana and Merab, and the harbours of Oman and Aden, received the precious cargoes of aromatics brought thither by the hardy camels of the Koreishites. Now, Mecca, the birth-place of Mahomet, is governed by a sherif, who is a temporal prince; and Medina, 200 miles north of Mecca, contains the tomb of the prophet. Sana, in Yemen, at the foot of a mountain called Nikkum, about four miles in circuit, is now the chief city of Arabia. Mocha is noted for its having one glass-house. The chief rivers are, the Euphrates and the Tigris, flowing through Irak-Arabia; and the chief range of mountains proceeds in the direction of the Red Sea, while the hills of Omon are merely a continuation of those on the other side of the Persian Gulf. Mount-Sinai is in Arabia-Petræa; and in the country of Seger there is a range of hills famous for producing frankincense. The horses of Arabia have long been celebrated; and the Kochlani breed are direct from the stalls of Solomon. But the chief animal is the camel, the ship of the desert. And the woods of Yemen abound in numerous monkeys; the jerboa, or rat of Pharaoh, is found in Neget; and wherever the mountains originate springs, to scatter verdure and fragrance, the antelope is there; and the wild oxen, wolves, foxes, and boars, pasture the woods, or prey on their inmates. The islands belonging to Arabia, are Socotra, in the Arabian Gulf, or Red Sea, about 240 miles from the southern coast, and celebrated for its aloes; and the isle of Bahrin, in the Persian Gulf, noted for its productive pearl fishery.

The Asiatic Islands.—These islands comprise those of the oriental archipelago; Australasia, and Polynesia. In the archipelago are the islands of Sunda, or the Sumatran chain, comprising Sumatra, Java, Balli, Lombok, Sumbava, Flores, and Timor. Sumatra, 950 miles long, and 200 broad, has an English settlement at Bencoolen. Though frost, snow, and hail, be unknown, the inland inhabitants of the mountainous districts use fire to dispel the cold; for true it is that a man may be frozen to death in the torrid zone. But these inland races are savages, covered with red hair, and little superior to the orang-outangs of Borneo. The elephant, the rhinoceros, the hippopotamus, the tiger, the bear, the otter, the porcupine, the wild hog, and the civet cat; herds of deer and troops of monkeys; wild poultry, the Argus pheasant, and swarms of destructive termites, comprise part of its zoology. Java, 650 miles long by 100 broad, is well known for its Dutch capital, Batavia, which is, in fact, the metropolis of the eastern archipelago. But Java is an unhealthy place, and "of three settlers it is rare that one outlives the year;" yet, to Batavia, Europeans and Chinese resort, the latter being contented, for the sake of gain, to forget the tombs of their ancestors, and the laws of Confucius, which interdict emigration. Balli furnishes slaves and cotton, the others spices; and the people of Timor are the bravest of these Oriental islanders.—Borneo, except New Holland, is the largest island in the world, being 900 miles in length, by 600 in breadth. The coasts are possessed by Malays, Moors, Macassars, from Celebez, and even Japanese. The natives in the interior are blacks, called Biajos, with lanky hair, of middle size, feeble, and inactive. Thousands of ourang-outangs are seen amidst the swamps and forests of this island. A knight of Borneo is known by his string of tigers' teeth, a chief of a tribe by having two of his front teeth replaced by two gold teeth. The capital of the island consists of 3000 houses built on posts, fixed in rafts, which are moored to the shore, and may be moved from place to place, according to the convenience or the caprice of the owners. The Manillas, or Phillippine islands, occupy a space of 20° of latitude, in the longitude of 120° and 130° east of Greenwich; and form a north-eastern frontier to the island of Borneo. Luzon, the largest of these islands, is 500 miles long, and 100 broad; and its chief city, Manilla, boasts a population of 12,000 Christians, mostly Spaniards. For it was between this island and Acapulco, that the Spanish galleons carried on their celebrated commerce, through a space of 8,400 miles of the ocean.—Mindanao is mountainous, but the vales are rich, being watered by numerous crystalline rivulets; and horses and buffaloes swarm in the interior. The remaining Phillippine islands are, Pulawain, Mindoro, Pani, Buglas, or the Isle of Negroes, Zebu, or Leita, and Samar. Maetan, a small isle, on the east of Zebu, is the place where the celebrated navigator, Magellan, was slain. These islands present many volcanic appearances; such as lava, volcanic glass, sulphur, and hot springs; and the bread-fruit extends its beneficial arms to the hundreds of islands that sprinkle the Indian and Pacific oceans.—The Celebezian Group, or the isles of Poison, are Celebez, Sanguy, Shullas, Peling, Boutan, and Sala. Celebez is 600 miles long, and about 60 broad, considering the extensive bays that chequer its coast. In its centre there are several live volcanoes. From the mountains, rivers precipitate themselves over vast rocks. The natives are called Macassars, and are famed most for their pusillanimous attacks on solitary vessels, with lances and arrows, poisoned with the juice of the deadly upas. Though these islands produce spices and rice, their botany is full of poisonous trees and plants.—The Moluccas are, Ternah, Tidore, Motir, Makian, and Bakian. Ternah is the retreat of the kingfisher, clothed in scarlet and mazareen blue; Tidore boasts five-and-twenty mosques, and its sultan claims tribute of Gilolo; Motir is the seat of Venus and voluptuousness; Makian rises out of the sea like a sugar-loaf; and Bakian is famed for its prodigious rocks of coral, of infinite variety and beauty.—The Spice Islands, are Gilolo, Ceram, Bouro, Mortay, Oubi, Mysol, Amboyna, and Banda. Gilolo, once governed by a sheref from Mecca, proves how far the Mahommedan conquests had extended. The natives are good weavers, and have plenty of oxen, buffaloes, goats, deer, and wild hogs, with bread-fruit and sago trees. Ceram abounds in clove trees, and large forests of sago trees; Bouro possesses the civet weasel, green-ebony, iron-wood, &c.; Mortay is full of sago trees; Mysol of birds of paradise; Oubi produces cloves; Amboyna boasts of a population of 17,800 Dutch Protestants; and 27,000 Mahommedans, Chinese, and savages. The clove tree in this island grows to the amazing height of forty or fifty feet, and will yield thirty pounds weight annually. But Banda is the chief isle in this group, furnishing 160,000 pounds weight of nutmegs, and 46,000 pounds of mace annually. The nutmeg tree grows to the size of the pear tree in our orchards; its leaves resemble those of the laurel; and from the age of 10 to 100 years it bears fruit. The nutmeg, on the tree, is about the size and colour of an apricot, but shaped like a pear. When ripe, the rind bursts, and discovers the mace, of a deep red, covering in part the thin shell of the nutmeg.

Australasia.—Australasia contains New Holland, Papua, or New Guinea, New Britain, and New Ireland, with the Solomon Isles; New Caledonia, and the New Hebrides, New Zealand; and Van Diemen's Land. New Holland is the largest island in the world, and some progress is now making in exploring its interior. From east to west it is 2,730 miles over; and from north to south 1,960 miles. The original inhabitants are harmless savages, grossly ignorant, believing in magic, witchcraft, and ghosts! At Port Jackson a colony has been formed for British convicts; but numerous free settlers are now established on the island, and it will, ere long, be famous, since the breed of sheep there rivals the Spanish Merinos, and the soil is excellent for grain. Papua, or New Guinea, partakes of the opulence of the Moluccas, with their singular varieties of plants and animals. And in the interior a race of savages, called Haraforas, live in trees, which they ascend by a notched pole, drawing it after them, to prevent surprise. The women are industrious, the men indolent, but fond of ornaments, as the tusks of boars around their necks, and feathers of the bird of paradise stuck in their woolly hair. Papua is the chosen abode of that splendid bird, of elegant parrots, and the crowned gigantic pigeon, nearly as big as a Norfolk turkey. New Britain resembles Papua in its inhabitants and products. The canoes of New Ireland are ninety feet long, formed out of single trees; and the inhabitants of the Solomon isles ornament their necks with gold beads. New-Caledonia, and the New Hebrides, have more intelligent inhabitants than we have lately been among, for their houses have carved door-posts, and the women are more chaste than in the other isles of the Pacific. Plantains, sugar-canes, yams, and several kinds of fruit-trees, are found in the Hebrides, whose natives are very dexterous in launching the spear, with unerring certainty. New Zealand consists of two large islands, which enjoy a temperate climate, equal to that of France; and the people believe that, the third day after they inter their dead, the heart is separated from the body, and carried to the clouds by an attendant spirit. Van Diemen's Land, an island situated south of New Holland, is about 160 miles long, and 80 broad. The natives and the products resemble those of New Zealand and New Holland.

Polynesia.—Polynesia is divided into the following islands, or groups.—The Pellew Islands, inhabited by a gentle and amiable race of industrious savages; the gay and innocent children of nature, united in one large family, by that concentration of society which small islands impose on their natives. The Ladrones, or Marians, of which the largest are Guam and Tinian, are inhabited by a people who resemble the natives of the Phillippines. These islands are fourteen in number, but only three are inhabited. North of the Ladrones are many small islands, with a few scattered islands on the north of the Carolines, that have not been classed and named. The Carolines, about thirty in number, are very populous, and the natives, like those of the Phillippines, live chiefly upon fish and cocoa-nuts. The three principal of these islands are, Hogoleu, Yap, and Ulea. The Sandwich Isles were discovered by Captain Cook, at the chief of which, Owhyhee, he lost his life. The inhabitants are mild, affable, and ingenious, but human sacrifices are frequent. The climate is more temperate than that of the West Indies. Dogs, hogs, and rats, are the native quadrupeds. The birds are pigeons, plovers, owls, and ravens. The bread-fruit tree abounds, and sugar-canes grow to an amazing size. The Marquesas boast no island half so large as Otaheite. Noaheva, the chief island of the Marquesas, is only about sixty miles in circumference. The natives possess the most exquisite symmetry of shape and regularity of features, and the women are as fair as the females in Italy and Spain, but mutual slaughter and human sacrifices prevail. The Society Islands amount to about seventy in number, of which Otaheite is the chief, being about 120 miles in circumference. The men are olive-coloured, the women brunettes, with fine black eyes, white and even teeth, soft skin, elegant limbs, jet-black hair, perfumed, and ornamented with flowers; but still they are inferior in beauty to the women of the Marquesas; nor do any of the females of the South-sea islands possess the Grecian forms and academical precision of feminine beauty. But the Otaheiteans are the Italians of the Great Pacific

Ocean in language and politeness, and in the romantic scenery of their country. Infants swim as soon as they can walk. The Friendly Islands, including the Feejee isles, the Navigators' islands, aod several more northerly and detached isles, are peopled by men of grave and regular behaviour, who are governed by despotic chiefs. The largest of these islands are, Pola, Tongataboo, Oyolava, Maouna, and Opoun. Provisions are amazingly plentiful in these islands. The men are of great stature, the women pretty and licentious. The inhabitants of all Australasia and Polynesia do not, perhaps, amount to 300,000 souls. The speech diffused throughout all the scattered islands of Polynesia is derived from the Malayan. The trees and plants peculiar to the tropical Pacific islands, are the bread-fruit tree, the plantain, the cocoa, the sugar-cane, figs, sweet potatoes, &c.

ASILUS, hornet fly.

ASPALATHUS, African broom.

ASPARAGUS, or *Sparrow Grass*, one of the greatest delicacies which our kitchen-garden affords, being particularly estimable from the early season at which it is produced. The asparagus is raised from seed, in beds formed for the purpose; and the plants should remain three years in the ground before they are cut; after which, for a dozen years, they will continue to afford a regular crop. In the Editor's garden there are some very fine beds about twenty years old.

ASPECT, the situation of the planets with respect to each other; there are 5 aspects: 1st. Sextile, marked ⚹, when the planets are 60° distant; 2dly, Quartile □, at 90°; 3dly, Trine, when 120° △; 4thly, Opposition ☍, when 180°; and 5thly, Conjunction ☌, when both in the same degree.

ASPEN TREE. the trembling poplar, flourishes in any situation; the wood, though good for packsaddles, milk pails, clogs, and wood-work for pattens, is very bad for beds, as it promotes insects.

ASPERIFOLIOUS, in Botany, one of the divisions or classes of plants in the Linnean system; so denominated because they are usually rough-leaved.

ASPERUGO, small wild bugloss.

ASPERULA, woodroof.

ASPHALTUM, bitumen Indiacum, pitch formed on the surface of the Dead Sea, and which was formerly employed in embalming the bodies of the dead.

ASPHODELUS, king's spear, asphodel.

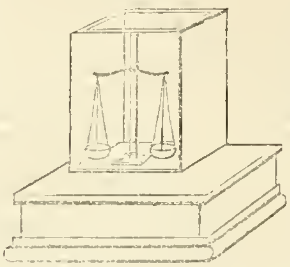
ASS, a species of æquus, or horse. When very young, the ass is sprightly, and even tolerably handsome; but he soon loses these qualities, and becomes dull, stupid, and headstrong. But he is not equally stupid in all countries; for in Spain, and some other countries, he is much more elegant and tractable; and if treated with care, there is no doubt that he might be rendered much more serviceable to us than he now is. Wild asses are fierce, swift, and formidable, and, when pursued, will defend themselves with courage.

ASSA-FŒTIDA, the concrete juice or resinous gum of a large umbelliferous plant, growing in India and Persia. The Banian Indians use it in all their dishes; our own cooks substitute it for garlic. In Arabia and Persia it is used both internally and externally as a medicine. It is an excellent cure for the hooping cough and for worms; in flatulent colics, &c.

ASSAULT, an attempt to offer to beat another without touching him; as if one lifts up his cane, a whip, or his fist, to hit another, or strikes at him, but misses him. The party injured may have redress by action of trespass *vi et armis*, wherein he shall receive damages as a compensation for injury. This teaches society the exterior formula of good breeding; but the temperament of an Englishman pricks him to repel force by force; and to repay by an eye for an eye, or a tooth for a tooth, without trusting to the doubtful issue of trespass, *per togam pecuniamque*.

ASSAYING. There are two kinds of assaying; one before metals are melted, the other after they have been struck; the first brings them to their proper fineness, and the last compares them with the standard. For the first assayers take 14 or 15 grains of gold, and half a drachm of silver, if it be for money; and 18 grains of the one, and a drachm of the other, if for other uses. The second assay is made of one of the pieces of money, which is cut into four parts. The quantity of gold for an assay is here six grains. Assaying is also the particular mode of examining every ore and mixed metal, according to its nature, with the proper fluxes, to discover not only what metals, with their proportions, are contained in ores, but also the quantity of sulphur, vitriol, alum, arsenic, and other matters. Gold is obtained pure by dissolving it in nitro-muriatic acid, and precipitating the metal by dropping in a diluted solution of sulphate of iron: the powder which precipitates is pure gold. Silver is obtained pure by dissolving it in nitric acid, and precipitating it with a diluted solution of sulphate of iron. With metallurgists the mass consists of 24 imaginary parts, called carats. Gold of 24 carats means pure gold: the number of carats mentioned specifies the parts of pure gold, and what that number wants of 24 carats, indicates the quantity of base metal in the alloy. Gold of 12 carats, means 12 parts of gold and 12 of another metal. Gold coins of Great Britain are of 22 carats fine; they contain, therefore, 11 parts of gold and one of copper. *Parting* is the separation of gold from silver, when both are contained in an alloy; and it is founded on the insolubility of gold, and the solubility of silver in nitric acid.

Fig. 108.



ASSAY BALANCE, is of very little different construction from the common scales, having a beam from 10 to 12 inches, and being made of the best steel. The beam is suspended in a fork, and as the balance will hardly stand still in the open air, it must be put into a case, as represented in the figure. A pair of pincers are used to put articles to be weighed into this balance; or if the article be a powder, a small shovel or spoon.

ASSIZE, an assembly of knights, and other substantial men, together with a justice, in a certain place, and at a certain time, when and where the writs, processes, whether civil or criminal, are decided by a jury, directed by a judge. If a man has been charged with an offence, before he can be put on his trial, the charge must first be examined by an impartial grand jury of 23 persons; twelve of whom, at least, must agree to find a bill of indictment, which being found, he then undergoes a public trial before twelve of his equals. The powers of a grand jury are most extensive, and their duties being most important, it is necessary that they be performed with the greatest care, intelligence, and impartiality. Bills ought never to be found lightly, on frivolous pretences, or imperfect evidence; and as grand juries only hear the evidence of the prosecutor, they ought to be vigilantly on their guard against trifling, vexatious, and malicious prosecutions. The petit jury of twelve make oath, that "they shall well and truly try, and true deliverance make, between the king and the prisoner at the bar, according to the evidence." After they have fully heard the evidence, the prisoner's defence, and the law from the judge, the twelve must decide each for himself, and the whole must be unanimous in acquitting, or in condemning, the prisoner. The jury must be impartial and independent, or they are liable to be challenged or objected to. They should also found their verdict on *their own* judgment, deducing it from clear and positive evidence: no other duty being so sacred, and no other trust so great, as that reposed in the integrity and independence of a juryman.

ASSOCIATION OF IDEAS, is when two or more ideas constantly and immediately follow or succeed one another in the mind, so that one shall constantly and infallibly succeed another. The influence of association in regulating the succession of our thoughts, is a fact familiar to all men: that one thought is often suggested to the mind by another, and that the sight of an external object often recalls former occurrences, and revives former feelings, are indisputable facts. This subject is very fully treated in the Editor's Grammar of Logic and Intellectual Philosophy. See chap. vii. book ii. of that work, second edition.

ASSUMPSIT, in Law, a voluntary or verbal promise, whereby a person assumes, or takes upon him, to pay any thing to another. There are numerous cases of assumpsit on record.

Thus all notes of hand, bills of exchange, &c. come under this name; and so of many other covenants, verbal or written.

ASSUMPTIVE Arms, in Heraldry. Thus, if a soldier, who has no right by blood to arms, or if he have none, shall in war captivate any gentleman, nobleman, or prince, he may then assume the arms of his prisoner, and enjoy them in his heirs for ever.

ASSURANCE on Lives. By assuring a life, is meant obtaining security for a sum to be received, should the life drop, in consideration of such a payment made to the assurer, as shall be a sufficient compensation for the loss and hazard to which he exposes himself. In estimating this compensation, the amount of it will depend entirely on the rate of interest at which money is improved, and the probable duration of the life of the individual. In order to illustrate this, let £100 be supposed to be assured on a life for a year to come, supposing money to bear an interest of 5 per cent. Now, first, if it were certain that the life would become extinct in the course of the year, the premium would be the present value of £100, payable a year hence, which at 5 per cent. would be £95. 4*s*. 8*d*.; but if, instead of the certain extinction of the life, it be known from the regular bills of mortality, that out of 1000 persons of the age of the assured, only 250 fall in the course of a year, or which is the same, if $\frac{250}{1000}$, or $\frac{1}{4}$, represent the prospect of its failing, then $\frac{1}{4}$ of the above premium will be the fair compensation to be received by the assurer: and as there have been tables of the decrease of human life kept for many years, in various parts of this and other kingdoms, the calculation of the fair premium to be paid for any age, for a year, is extremely simple, and needs no farther illustration. But the assurances most commonly practised, are those on single lives, either for a given term, or during their whole continuance; and the premium is either paid in a single present payment, or in annual payments during the said term, or till the life fails; in both which cases the calculation becomes more complicated. On the most equitable principles, tables have been computed which exhibit at one view the annual payment that ought to be made to assure a life, at any age, for £100; and which, therefore, is equally applicable for any other sum, by a simple operation of multiplication and division; these annual payments vary a little in different offices, but the most general terms and conditions are as follows:—The person making the assurance is to declare the place and date of birth of the person whose life is to be assured; whether he have had the small-pox; whether subject to the gout; and whether in the army or navy.

Conditions of Assurance made by Persons on their own Lives.—The assurance to be void, if the person whose life is assured shall depart beyond the limits of Europe, shall die upon the seas, (except in his majesty's packets passing between Great Britain and Ireland,) or shall enter into or engage in any military or naval service whatever, without the previous consent of the company; or shall die by suicide, duelling, or the hand of justice; or shall not be, at the time the assurance is made, in good health.

Conditions of Assurance made by Persons on the Lives of others.—The assurance to be void, if the person whose life is assured shall depart beyond the limits of Europe, shall die upon the seas, (except in his majesty's packets passing between Great Britain and Ireland,) or shall enter into, or engage in any military or naval service whatever, without the previous consent of the company; or shall not be, at the time the assurance is made, in good health. These rules are varied conditionally in some assurance offices; but we have exhibited the general principles. Any person making an assurance on the life of another, must be interested therein, agreeably to act of 14th of Geo. III. chap. 48, which prohibits wagering, or speculative insurances.

Since the foregoing was written for this work, some new assurance associations have arisen, which take numerous risks that the old offices would not assure; and it matters not now, whether a man belong to the army, the navy, or any other service equally hazardous: he may assure at some of these new offices with as much facility as a tradesman could do at the Sun, the Equitable, or the Rock life-assurance offices.

Table of Premiums

For Assuring the Sum of One Hundred Pounds upon the Life of any healthy Person, from the Age of Eight to Sixty-seven.

Age.	One Year.			7 Yrs. at an ann. payment of			The whole Life, at an annual payment of			Age.	One Year.			7 Yrs. at an ann. payment of			The whole Life, at an annual payment of		
	£.	s.	d.	£.	s.	d.	£.	s.	d.		£.	s.	d.	£.	s.	d.	£.	s.	d.
8 to 14	0	17	9	1	1	5	1	17	7	8 to 41	2	2	0	2	5	4	3	9	9
15	0	17	11	1	2	11	1	18	7	42	2	3	6	2	6	6	3	11	8
16	0	19	2	1	4	7	1	19	8	43	2	4	6	2	7	9	3	13	8
17	1	1	2	1	6	1	2	0	8	44	2	5	6	2	9	2	3	15	9
18	1	3	3	1	7	5	2	1	8	45	2	6	8	2	10	10	3	17	11
19	1	5	0	1	8	6	2	2	8	46	2	7	10	2	12	6	4	0	2
20	1	7	3	1	9	5	2	3	7	47	2	9	0	2	14	4	4	2	7
21	1	8	10	1	10	1	2	4	6	48	2	10	3	2	16	4	4	5	1
22	1	9	3	1	10	6	2	5	4	49	2	12	3	2	18	6	4	7	10
23	1	9	8	1	11	0	2	6	3	50	2	15	1	3	0	8	4	10	8
24	1	10	2	1	11	6	2	7	1	51	2	17	4	3	2	8	4	13	6
25	1	10	7	1	12	1	2	8	1	52	2	19	1	3	4	9	4	16	5
26	1	11	1	1	12	7	2	9	1	53	3	1	0	3	7	0	4	19	7
27	1	11	7	1	13	2	2	10	1	54	3	3	0	3	9	5	5	2	10
28	1	12	1	1	13	9	2	11	1	55	3	5	0	3	12	0	5	6	4
29	1	12	8	1	14	4	2	12	3	56	3	7	3	3	14	8	5	10	1
30	1	13	3	1	14	11	2	13	5	57	3	9	8	3	17	6	5	14	0
31	1	13	9	1	15	7	2	14	7	58	3	12	3	4	0	6	5	18	2
32	1	14	4	1	16	3	2	15	9	59	3	15	1	4	3	8	6	2	8
33	1	15	0	1	16	10	2	17	1	60	3	18	1	4	7	1	6	7	4
34	1	15	8	1	17	8	2	18	5	61	4	1	5	4	10	11	6	12	4
35	1	16	4	1	18	10	2	19	10	62	4	3	11	4	15	0	6	17	9
36	1	17	0	1	19	7	3	1	4	63	4	7	8	4	19	8	7	3	7
37	1	17	9	2	0	8	3	2	10	64	4	10	9	5	4	10	7	9	10
38	1	18	6	2	1	9	3	4	6	65	4	15	2	5	10	10	7	16	9
39	1	19	3	2	2	11	3	6	2	66	5	0	1	5	17	7	8	4	1
40	2	0	8	2	4	1	3	7	11	67	5	5	6	6	5	2	8	12	1

ASTER, in Botany, starwort, so called as having a radiated flower.

ASTERIA, the goshawk; also the gem cat's eye: the name also of an extraneous fossil, known as star-stone.

ASTERIAS, the star fish, or sea star.

ASTERION and Chara, or *Canes Venatici*, the Greyhounds. This constellation was introduced by Hevelius. It occupies the western space between Boötes and the hind legs of Ursa Major, and is easily distinguished by a star of the 3d magnitude on the neck of Chara, forming a triangle with γ and η, in the hip and tail of Ursa Major. Sir Charles Scarborough, physician to Charles II. called this star *Cor Caroli*, or Charles's Heart, in honour of king Charles I.

A-STERN, denotes any distance behind a ship, as opposed to A-head.

ASTRAGAL, in Architecture, a round moulding, which, in the orders, surrounds the top of the shaft or body of the column; it is used also at the bottoms as well as the tops of columns; and properly represents a ring on whatever part of a column it is placed.—In Anatomy, the upper bone of the tarsus, which, by its conjunction with the bones of the leg, forms the ankle-joint.

ASTRAGALUS, milk, or liquorice vetch.

ASTRANTIA, masterwort.

ASTRINGENTS, in Medicine, are distinguished by a rough austere taste, and the property of changing solutions of iron, especially those made in the vitriolic acid, into a dark purple or black colour; such as galls, tormentil root, terra japonica, acacia, &c.

ASTROITES, star stone.

ASTROLABE, a stereographic projection of the sphere, which, among the ancients, was equivalent to the armillary sphere, or armed by proper graduations, &c. it enabled an observer to take the altitude of the sun, or of a star.

ASTROLOGY, a conjectural science, founded upon certain supposed effects, influences, positions, and situations of the stars, with a view to predict future events from their aspects, &c. It surprises one, that our almanack makers should still repeat the nonsensical stuff of Lilly, Moore, and other clever men, who reigned in the ages of judicial, perhaps natural, astrology.

ASTRONOMY, the science which teaches the motions of the Earth, the Sun, Moon, Planets, Comets, and Stars, and explains the phenomena occasioned by those motions, is divided into two parts: 1st. that which treats of the motions, magnitudes, and periods of the revolutions of the heavenly bodies, and is called *pure* or *plain Astronomy;* 2d. that which investigates the causes and laws by which these motions are regulated. The student of astronomy may, in the day time, observe one of the chief of these motions in the rising, ascent, exaltation, declension, and setting of the sun. In the morning he will see it rise in the eastern heavens, ascend in this hemisphere towards the south, attain its greatest height at noon, and then descend again, till it sets in the west, as far from the south as it rose in the morning. This is the *first* practical lesson in astronomy. In the night time he may observe the stars rise in the east, ascend towards the south, and decline and set to the west; and this will be the *second* lesson. He may, however, observe, that one star, *viz.* that over the North Pole, never moves, and that all the others move around it, and those within a certain distance never set; and, in short, in this *third* lesson, which is worthy of being pursued through successive evenings, he will become master of the general motions of the heavens. Thus, by measuring, for example, at London, during a long winter's night, the two meridian heights of the Polar Star. (*a Ursæ Minoris*, having 88° 20′ 49″ declination N.) we find that (ann. 1820)

When it passes above the Pole, its altitude measures	53° 10′ 11″
And when it passes below the Pole, it measures	49° 51′ 49″
The sum of which is	103° 02′ 00″
And their half	51° 31′ 00″

Which will be the altitude of the Pole above the horizon of London, or the distance of this city from the equator. If, on the contrary, we subtract 49° 51′ 49″ from 53° 10′ 11″, we shall find for their difference 3° 18′ 22″, of which the half, 1° 39′ 11″, will give the distance of the Polar Star from the Pole (in 1820), which we thus find does not exactly occupy this point, but is yet very near to it. He will observe, in a *fourth* lesson, which is also to be pursued through successive nights, that the moon changes her place with regard to the stars, that she increases in light in proportion to her increased distance from the sun, till she arrives at the opposite, or rises as the sun sets; and that the light increases on one side, and decreases on the other, being always towards the sun. He will, in like manner, observe, that the planets change their motions slowly in regard to the fixed stars, and that both the moon and the planets move in the same line, or nearly so, among the fixed stars; and this *fifth* lesson may be mixed with others through successive weeks. He will be highly gratified by applying any telescope (the larger the better, but the smallest will afford much gratification) to the moon, planets, and stars. He will observe the decrease and increase, and change of the shadows of the moon's pits; the satellites of Jupiter; the moon-like appearance of Venus; the ring and moons of Saturn; and many of the constellations and nebulous clusters of stars.

The heavenly bodies that we are to notice, are, the *Sun*, the *Planets*, *Comets*, and *Fixed Stars*.

The Sun gives name to the system of Astronomy, which Copernicus, Kepler, and Newton have established, but which was known in the East 4000 years ago, in its general appearances, as perfectly as by La Place in our own times. The solar system is so called, because the Sun is supposed to be situated in a certain point, termed the centre of the system, having all the planets revolving round him at different distances, and in different periods of time. This is likewise called the Copernican system. *See Plate* Solar System.

The SUN, situated near the centre of the orbits of all the planets, revolves on its axis in 25 days 14 hours 4 minutes. This revolution is determined from the motion of the spots on its surface, which first make their appearance on the eastern extremity, and then by degrees come forwards towards the middle, and so pass on till they reach the western edge, and then disappear. When they have been absent for nearly the same period of time which they were visible, they appear again as at first, finishing their entire circuit in 27 days 12 hours 20 minutes.* The Sun is likewise agitated by a small motion round the centre of gravity of the solar system, occasioned by the various attractions of the surrounding planets; but as this centre of gravity is generally within the body of the Sun, and can never be at the distance of more than the length of the solar diameter from the centre of that body, astronomers generally consider the Sun as the centre of the system, round which all the planets revolve; though in reality the centre of gravity of the Sun, and of all the planets, is the *centre of the world.* As the Sun revolves on an axis, his figure is supposed not to be strictly in the form of a globe, but a little flatted at the poles; and that his axis makes an angle of about eight degrees, with a perpendicular to the plane of the earth's orbit. As the Sun's apparent diameter is longer in December than in June, it follows that the Sun is nearer to the earth in our winter than it is in summer; for the apparent magnitude of a distant body diminishes as the distance increases. The mean apparent diameter of the Sun is stated to be 32′ 2″; hence, taking the distance of the Sun from the earth to be 95 millions of miles, as is now determined, its real diameter will be 886,149 miles; and, as the magnitudes of all spherical bodies are as the cubes of their diameters, the magnitude of the Sun will be 1,377,613 times that of the earth; the diameter of the earth being 7964 miles, the diameter of the Sun is above 111 times the diameter of the earth. When we consider the Sun as the fountain of light that illuminates this universe, and that causes the earth to produce every thing desirable for man, may we not consider it also as an eminent, large, and lucid planet, evidently the primary one of our system; Mercury, Venus, the Earth, and all the others, being its secondaries? And considering its solidity, its atmosphere and diversified surface, its rotation on its axis, and all the circumstances attending this glorious globe, may we not conclude that it is inhabited, like the other planets, by beings whose organs are adapted to the physical properties of the Sun. This seems to be a more pleasing and agreeable way of making the tour of creation, than joining issue with fanciful poets, who have pronounced it the abode of blessed spirits; or closing with the chilling doctrines of angry moralists, who have fancied it the fittest residence for the punishment or purgation of the wicked from off the earth.

The PLANETS.—There are eleven planets belonging to our system. Six of these have been recognized from time immemorial: namely, Mercury, Venus, the Earth, Mars, Jupiter, and Saturn. But the remaining five, invisible to the naked eye, have lately been discovered by the help of the telescope; and are therefore called telescopic planets: namely,

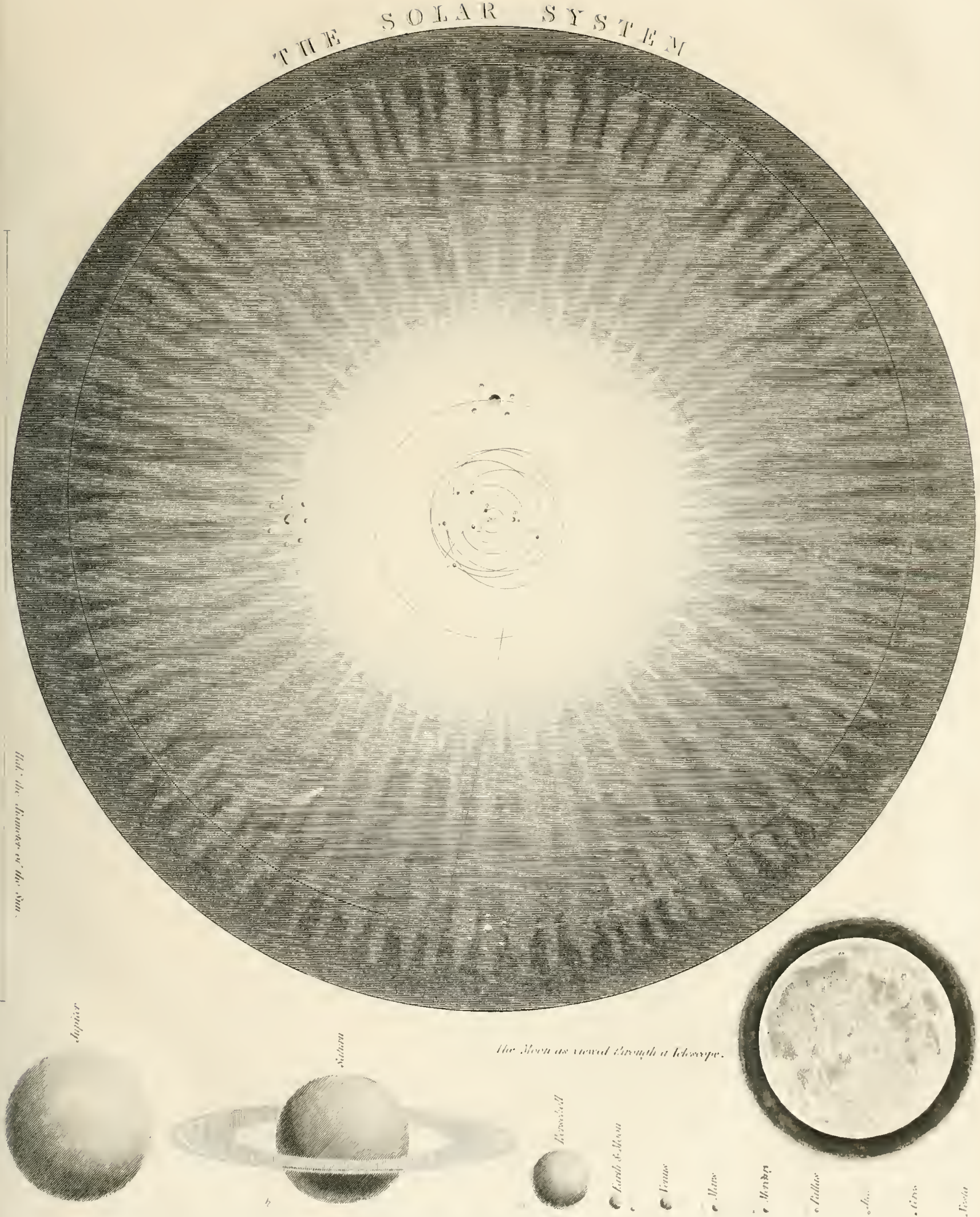
Uranus, discovered by	Dr. Herschel,	March 13, 1781.
Ceres	M. Piazzi,	January 1, 1801.
Pallas	M. Olbers,	March 28, 1802.
Juno	M. Harding,	Septem. 1, 1803.
Vesta	M. Olbers,	March 29, 1807.

All these Planets revolve round the sun, as the centre of motion; and in performing their revolutions they follow the laws of planetary motion discovered by Kepler, and confirmed by subsequent observations. These laws are, The orbit of each planet is an ellipse; of which the sun occupies one of the foci. That focus is called the lower focus. If we suppose the plane of the earth's orbit, which passes through the centre of the sun, to be extended in every direction, as far as the fixed stars, it will mark out a great circle among them, which is the ecliptic; and with this the situations of the orbits of all the other planets are compared. The planes of the orbits of all the other Planets must necessarily pass through the centre of the sun, but if extended as far as the fixed stars, they form circles different from each other, as also from the ecliptic; one

---

* M. Cassini determined the time which the Sun takes to revolve on its axis, thus: the time in which a spot returns to the same situation on the Sun's disc, (determined from a series of accurate observations,) is 27 days 12 hours 20 minutes; now the mean motion of the earth in that time is 27° 7′ 8″ · hence 360° + 27° 7′ 8″ : 27d. 12h. 20 m. : : 360° : 25d. 14h. 4m. the time of rotation.

THE SOLAR SYSTEM



The Moon as viewed through a telescope.

Comparative Magnitude of the Planets.

Published by H. Fisher Caxton Press [illegible] June 1825.

J. W

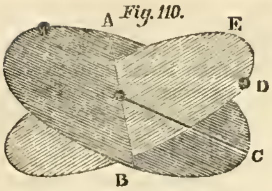


Fig. 110.

part of each orbit, is on the north, and the other on the south side of the ecliptic. Therefore the orbit of each planet cuts the ecliptic in two opposite points, as A B, fig. 110, which are called the *nodes* of that particular planet; and the nodes of one planet cut the ecliptic in planes different from the nodes of another planet. The line A B is called the line of the nodes. The ascending node is that where the planet passes from the south to the north side of the ecliptic. The angle E G is the inclination of the planes of the two orbits to each other. The descending node, that where the planet passes from the north to the south side of the ecliptic. Perigee, when the sun and moon are nearest the earth; apogee, when at their greatest distance. The extremity of the major axis of this ellipse, nearest the sun, is called the perihelion; the opposite extremity of the same axis is called the aphelion. The line, which joins these two points, is called the line of the apsides. The radius vector is an imaginary line drawn from the centre of the sun to the centre of the planet, in any part of its orbit. The velocity of a planet in its orbit is always greatest at its perihelion. This velocity diminishes as the radius vector increases, till the planet arrives at its aphelion, when its motion is the slowest. It then increases in an inverse manner, till the planet arrives again at its perihelion. The areas, described about the sun by the radius vector of the planet, are proportional to the times employed in describing them; and these laws are sufficient for determining the motion of the planets round the sun; but it is necessary to know, for each of these planets, seven quantities; which are called the elements of their elliptical motion. The first five of these elements relate to the motion in an ellipse; the last two relate to the position of the orbit, since the planets do not all move in the same plane; agreeably to the following tables of La Place, calculated for the commencement of the present century.

1. *Duration of the Sidereal Revolution.*

	Days.		Days.
Mercury	87·929+	Ceres	1681·539+
Venus	224·700+	Pallas	1681·709+
Earth	365·256+	Jupiter	4332·569+
Mars	386·979+	Saturn	10758·969+
Vesta	1335·205+	Uranus	30689·712+
Juno	1590·998+		

2. *The Mean Distance of the Planets from the Sun.*

Mercury	·3870381	Ceres	2·7674060
Venus	·7233323	Pallas	2·7675920
Earth	1·0000000	Jupiter	5·2027911
Mars	1·5236935	Saturn	9 5387705
Vesta	2·3730000	Uranus	19·1833050
Juno	2·6671630		

3. *Ratio of the Eccentricity to Half the Major Apsis.*

Mercury	·20551494	Ceres	·07831860
Venus	·00685298	Pallas	·24538400
Earth	·01685318	Jupiter	·04817840
Mars	·09322000	Saturn	·05616830
Vesta	·09322000	Uranus	·04667030
Juno	·25404400		

4. *Mean Longitude.*

Mercury	182° 15647	Ceres	294° 16820
Venus	11 93672	Pallas	280 68580
Earth	111 28179	Jupiter	124 67781
Mars	71 24145	Saturn	150 38010
Vesta	297 12990	Uranus	197 54244
Juno	322 79380		

5. *Mean Longitude of the Perihelion.*

Mercury	82° 6256	Ceres	162° 9565
Venus	142 9077	Pallas	134 7040
Earth	110 5571	Jupiter	12 3812
Mars	369 3407	Saturn	99 0549
Vesta	277 4630	Uranus	185 9574
Juno	59 2349		

6. *Longitude of the Ascending Node.*

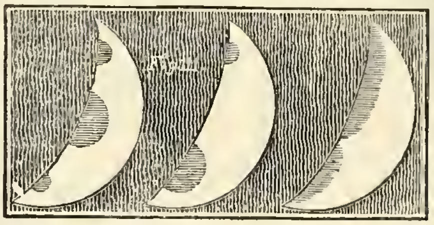
Mercury	51° 0651	Ceres	89° 9083
Venus	83 1972	Pallas	191 7148
Earth	0 0000	Jupiter	109 3624
Mars	53 3605	Saturn	124 3662
Vesta	114 4630	Uranus	80 9488
Juno	190 1228		

7. *Inclination of the Orbit to the Ecliptic.*

Mercury	7° 78058	Ceres	11° 80680
Venus	3 76936	Pallas	38 46540
Earth	0 00000	Jupiter	1 46034
Mars	2 05663	Saturn	2 77102
Vesta	7 94010	Uranus	0 85990
Juno	14 50860		

The examination of the first two tables will shew us, that the duration of the revolutions of the planets increases with their mean distance from the sun. Whence Kepler discovered his third fundamental law; namely, The squares of the times of the revolutions of the Planets are to each other as the cubes of their mean distances. But then the ellipses which the Planets describe, are not unalterable: their major axes are the same; but their eccentricities, the positions of their perihelion nodes, with the inclination of their orbits to the ecliptic, seem to vary in a course of years.

Mercury ☿, the least of the inferior planets, and yet nearest to the sun, is 36,814,721 miles from that luminary. This planet emits a bright white light, and sometimes appears a little after sunset, and again a little before sunrise: but as this planet is so very near the sun, and of itself very small, we seldom see him without a telescope. As seen through a telescope, Mercury exhibits all the phenomena of the moon, which shews that it receives its light from the sun, as does our earth. The periodical revolution, mean distance from the sun, &c. of Mercury, are all given in the foregoing tables. The best observations of this planet are those made when it is seen on the sun's disc or face, called the *transit of Mercury*. The last transit happened in 1822, and the intervals are very remote. The apparent diameter is about eleven seconds; hence the real diameter is 3108 miles, or about one-sixteenth of the magnitude of the earth.



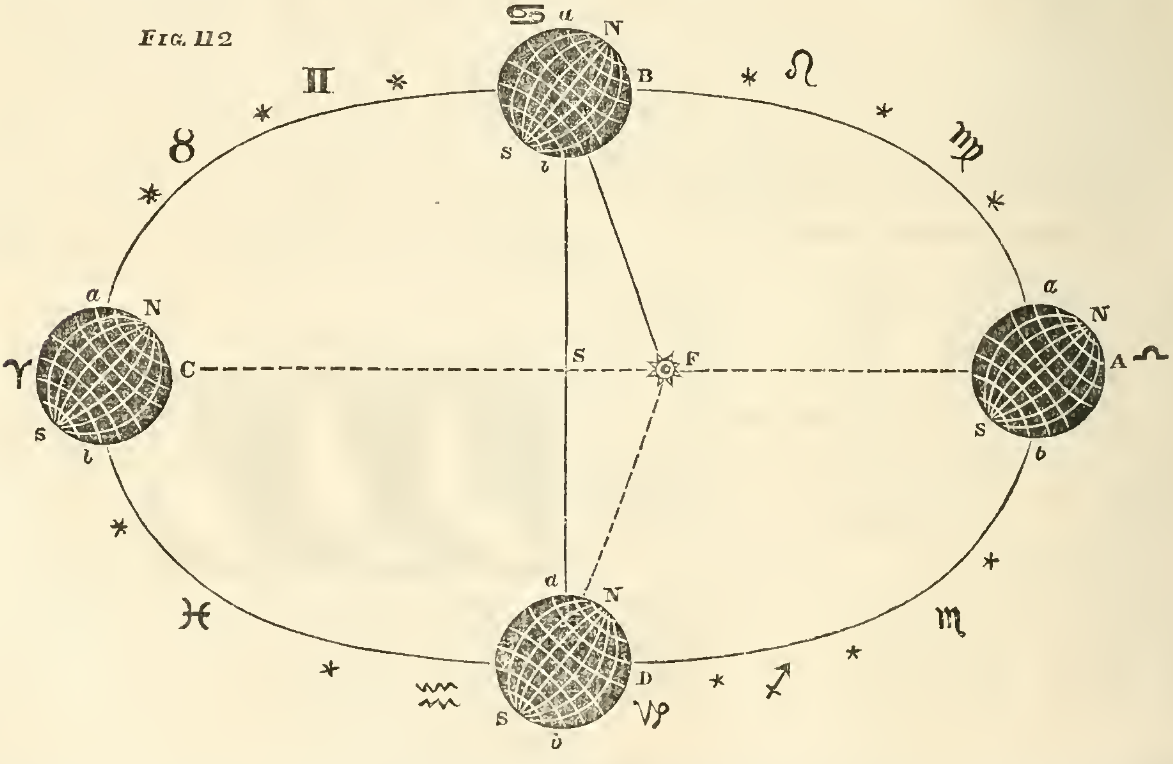
Venus, ♀, Fig. 111.—Venus, the next planet above Mercury, is computed to be sixty-eight millions of miles from the sun, and by moving at the rate of seventy-six thousand miles an hour, she completes her annual revolution in 224 days and 16 hours, 49′ 11″ and a half, and her synodical revolution is about 548 days. Her diameter is seven thousand seven hundred miles, or nearly the size of our earth, and her diurnal rotation on her axis is performed in 23 hours 21 minutes and 7″. Venus is often seen by the unassisted eye in broad daylight. The proportion of light and heat received by this planet from the sun is 1·91 times greater than the earth. And it is surrounded with an atmosphere, the refractive powers of which differ very little from ours. Like Mercury, it sometimes passes over the sun's face, and its transit has been applied to one of the most important problems in astronomy, as by it the true distances of the planets from the sun have been determined. These transits take place in the months of June and December. The first will be on the 8th December, 1874. When Venus is to the west of the sun, it rises before the sun, and is called a morning star; this appearance continues about 290 days together; when this planet is to the east of the sun, it sets after the sun, and is called an evening star for about the same period of 290 days. Venus appears the brightest of the planets; it has a considerable atmosphere, and some astronomers assert, that they have discovered mountains on its surface. At times this planet appears gibbous like the moon, fig. 111.

The Earth, ⊕, fig. 112.—The Earth which we inhabit is the planet next in order; hence we say, Mercury and Venus are inferior; but all the planets which are further from the sun than the Earth is, are superior planets. The Earth is 93 millions of miles from the sun; it performs its sidereal revolution in $365^{d}\ 6^{h}\ 9'\ 11''\ 5$; and it passes from the one tropic, to the same again, in only $365^{d}\ 5^{h}\ 48'\ 51''\ 6$. The axis of the Earth is inclined to the plane of the ecliptic in an angle of 23° 27′ 57″, and the points of intersection are called the equinoctial points; and the ecliptic is the path of the Earth in its annual revolution round the sun.

There are several ways of shewing, that the Earth upon which we live is spherical, like an orange; and this is the form of all the planets. The shadows of bodies in general take the form of their originals. The shadow of the Earth on the moon, that is to say, an eclipse of the moon is, *circular:* the Earth is, therefore, *globular*. Several navigators, by sailing westward, have reached the port they first left. They must, therefore, have sailed round a globular surface. And they have observed, that on leaving land the shores first disappeared, then the hills. On the contrary, approaching land, mountains are first seen, then the shores. These facts also corroborate our illustration of the Earth's sphericity. The Earth is supposed to be surrounded by various lines, that indicate portions of its surface, or enable us to perform the mechanical operations of Geography, Navigation, and Astronomy. The *axis* of the Earth is an imaginary line passing through its centre. Upon this line it is supposed to turn in its diurnal revolution. The *poles* of the Earth are the extremities of its axis. The lines or circles surrounding the Earth are of two names, *great* and *small*. All great circles divide the Earth into two equal portions; all small circles cut it in unequal parts. The *equator* is a great circle equidistant from both poles. The latitudes of places are reckoned north or south of the equator, as they lie on either side of that line. *Meridians* are great circles of the Earth, crossing the equator at right angles, and terminating in the poles. *Parallels* of latitude are less circles, drawn parallel to the equator. The *longitude* of a place is the distance of the meridian of that place, east or west, from the first meridian. As the Earth revolves round its axis daily from west to east, the heavenly bodies appear to a spectator on the Earth to revolve in the same time from east to west, and the alternate succession of day and night is the effect of the revolution of the Earth towards and from the sun. For all the heavenly bodies appearing to move from east to west, while the Earth revolves from west to east, the sun will appear, in each revolution, to rise above the horizon in the east, and after describing a portion of a circle, to set in the west, and will continue below the horizon, till, by the revolution of the Earth, it again appears in the east: and thus day and night are alternately produced.

The Sun is supposed to be fixed, not in the centre of the Earth's elliptical orbit, but in one of the foci. Let F represent the Sun, (fig. 112) and A B C D the Earth's elliptical orbit. Then A is the perihelion, or lower apsis, being the Earth's nearest distance from the Sun; C is the aphelion, or higher apsis, being its greatest distance; and the distance between the Sun (in the focus) and the centre S, is called the eccentricity of the Earth's orbit. If from the centre there be erected upon the axis a perpendicular meeting the orbit in L, a point in the centre of the figure B, and the line F L be drawn, it will represent the Earth's mean distance from the Sun, being equal to half the axis A C, consequently F L is 95 millions of miles. The phenomena of the different seasons of the year will appear from the following observations:—Let A B C D represent the Earth's annual orbit, with the Sun in the focus F; *a b*, an imaginary line through the Earth's centre, perpendicular to this plane; the axis N S, of the Earth, forming an angle of 23° 28′ with this perpendicular: then if the Earth move in A, B, C, D, so that N S may always remain parallel to itself, with the same angle to *a b*, it will denote the seasons; for, a line drawn from the Sun to the Earth, the Sun will be vertical to that part cut by this line. Now, when the Earth is in Libra ♎, the Sun will appear in Aries ♈, and we have *Spring*, the days and nights are equal in both hemispheres, and the season a medium between summer and winter; the line dividing the dark and light hemispheres, passes through the poles N and S, dividing all the parallels of latitude, as P R, equally; hence all the inhabitants of the Earth have their days and nights equal, *viz.* twelve hours each. While the Earth moves from Libra ♎ to Capricorn ♑, the north pole N will be more enlightened, and

FIG. 112



the south pole S more darkened; hence the days in the northern hemisphere will increase, and in the southern hemisphere decrease, the parallels of latitude being unequally divided. When the Earth has arrived at Capricorn ♑, the Sun will appear in Cancer ♋: this period is a medium between spring and autumn, and is called *Summer* in the northern hemisphere; in the southern, winter then reigns; at the north pole, and within the arctic circle, there will be constant day; at the south pole, and within the antarctic circle, constant night. While the Earth moves from Capricorn ♑ to Aries ♈, the south pole will be more enlightened; consequently, the days in the southern hemisphere will increase, and decrease in the northern hemisphere. When the Earth has arrived at Aries ♈, the Sun will appear in Libra ♎, and the days and nights be again equal all over the Earth: this period is a medium between summer and winter, and is called *Autumn*. Again, as the Earth moves from Aries ♈ towards Cancer ♋, the light will gradually leave the north pole and proceed to the south: when the Earth has arrived at Cancer ♋, it will be summer in the southern hemisphere, and winter in the northern: the south pole will have continual day, the north pole constant night: this period is a medium between autumn and spring, and is denominated *Winter*. Lastly, while the Earth moves from Cancer ♋ to Capricorn ♑, the Sun will appear to move from Capricorn ♑ to Cancer ♋, and the days in the northern hemisphere will increase, while those in the southern diminish; and while the Earth moves from Capricorn ♑ to Cancer ♋, the Sun will appear to move from Cancer ♋ to Capricorn ♑, the days in the northern hemisphere will decrease, and those in the southern increase. In all situations of the Earth, the equator will be divided equally; consequently, the days and nights at the equator are always equal. Thus, the different seasons are clearly accounted for, by the inclination of the Earth's axis, the plane of its orbit combined with the parallel motion of that axis.

The axis of the Earth, in its circuit round the sun, being inclined to the plane of its orbit, this inclination occasions the succession of the four seasons. The Earth's axis makes an angle of 66° 32′ with its orbit, that is, with the ecliptic, and always preserves its parallelism, or is directed towards the same point in the heavens; hence during one half of the year the north pole is continually illuminated by the sun, and the south pole is all that time in darkness; and during the other half the year, the south pole is constantly in the light, and the north pole is in darkness; and other parts in a proportional degree partake of this vicissitude, and create the variety of the seasons. The difference in the degrees of heat, is owing chiefly to the different heights to which the sun rises, and the different lengths of the days. When the sun rises highest, in summer, its rays fall less obliquely, and consequently more of them fall on any given portion of the Earth's surface than in winter, when the rays fall obliquely; and when the days are long, and the nights short, the earth and air are more heated in the day than they are cooled in the night, and the reverse when the days are short and the nights long. The lengthening and shortening of the days, and the different seasons, are produced by the motion of the Earth, N S, fig. 112, in its orbit round the sun, F. The axis of the Earth N S inclines to the plane of the orbit, and is parallel to itself in all parts of the orbit. In June the north pole N inclines to the sun, and it is summer in the northern parts of the earth; in December the north pole declines from the sun, and it is winter in the northern and summer in the southern hemisphere.

There are several ways of demonstrating that the planets move round the sun; thus, Mercury and Venus always appear in the neighbourhood of the sun, and if the sun revolved round the Earth as a centre, so must these planets; but if they did, then the motion of each would always appear to us nearly equable, and in the same direction; whereas now they are sometimes stationary, or have no proper motion; sometimes they move eastward in reference to the fixed stars, and their motion is then called direct, progressive, or *in consequentia*; sometimes they move westward, and have a retrograde motion, when they are said to move *in antecedentia*; appearances which are necessary, when we admit the sun to be the centre of their orbits, and of the Earth's, but wholly irreconcileable with any other hypothesis.

Moreover, when Mercury and Venus appear in conjunction with the sun, they are sometimes hid behind the body of the sun, and sometimes pass between it and the Earth, appearing like a dark spot on the sun's disc or face; but if they have latitude, when in their superior conjunction, that is, when beyond the sun, they shine with a face perfectly circular, like a full moon. But the face disappears in their inferior conjunction, that is, when between us and the sun, as the moon does at her change; whence it is evident, that their orbits are between the sun and the orbit of the Earth. Mars sometimes appears in opposition to the sun, which proves that its orbit includes that of the Earth; and that it includes the sun is plain, otherwise Mars would, in its conjunction with the sun, disappear, like Mercury and Venus, which never happens: the same may be observed of Jupiter, Saturn, and Herschel. The motions of the Earth in its orbit are proved, by the effect of its motion on the apparent motions of the several planetary bodies. These, as the Earth happens to be situated, become stationary, retrograde, or direct, and the variations are exactly measured by motions referred to the Earth, like the motions of objects ashore, when we are moving in a boat.

As the Earth revolves round the sun in 365 days, 6 hours, 56 minutes, 4 seconds, the sun appears to revolve round the Earth in the same time, but in the contrary direction. It is manifest, that the circle in which the sun appears to move, is the same in which the Earth would appear to move to a spectator in the sun. Hence the apparent place of the sun being found, the true place of the Earth in its orbit is known to be 180° distant. The orbit in which the Earth revolves round the sun, fig. 112, is an ellipse, having the sun in one of its foci. For the computations of the sun's place, upon this supposition, allowing for the disturbing forces of the planets, are found to agree with observations. The circle which the sun appears to describe annually among the more distant fixed stars, is called the Ecliptic; and a portion of the heavens, about 16 degrees in breadth, through the middle of which the ecliptic is traced, is called the Zodiac, in which the orbits of all the planets are described by their respective revolutions. The stars round the Zodiac are classed in 12 *signs:* Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricorn, Aquarius, Pisces. Figures, representing these signs, are drawn in Dr. Jamieson's Celestial Atlas, and upon the Celestial Globe, in that portion of its spherical surface which corresponds to the portion of the concave sphere of the heavens in which the stars belonging to each sign are respectively found.

Spring Signs.	*Summer Signs.*
♈ *Aries*, the Ram, 21st March.	♋ *Cancer*, the Crab, 21st June.
♉ *Taurus*, the Bull, 19th April.	♌ *Leo*, the Lion, 22d July.
♊ *Gemini*, the Twins, 20th May.	♍ *Virgo*, the Virgin, 22d Aug.

These are called Northern Signs, being north of the equinoctial.

Autumnal Signs.	*Winter Signs.*
♎ *Libra*, the Balance, 23d September.	♑ *Capricornus*, the Goat, 21st December.
♏ *Scorpio*, the Scorpion, 23d October.	♒ *Aquarius*, the Water-bearer, 20th January.
♐ *Sagittarius*, the Archer, 22d November.	♓ *Pisces*, the Fishes, 19th February.

These are called southern signs. The spring and autumnal signs are called ascending signs; because when the sun is in any of these, his declination is increasing. The summer and winter signs are called descending signs; because when the sun is in any of these, his declination is decreasing.

The axis of the Earth in every part of the Earth's revolution about the sun, makes, with the plane of its orbit, that is, of the ecliptic, an angle of 66½ degrees, consequently the planes of the equator and ecliptic make with each other an angle of 23½ degrees nearly, being the complement of 90 degrees. The obliquity of the ecliptic is not permanent, but is continually diminishing by the ecliptic approaching nearer to a parallelism with the equator, at the rate of about half a second in a year, or from 50″ to 55″ in 100 years. The inclination at this time is 23° 27′ 46″ nearly. The diminution of the obliquity of the ecliptic to the equator, is owing to the action of the planets upon the earth, especially the planets Venus and Jupiter. The whole diminution, it is said, can never exceed one degree, when it will again increase. The diminution of the obliquity of the ecliptic is a consequence of the approach of the Earth's axis towards a perpendicular direction to the plane of the ecliptic; but the Earth's axis has, besides the progressive motion, a tremulous one, by which its inclination to the plane of the ecliptic varies backwards and forwards some seconds: the period of these variations is nine years. The tremulous motion is termed the nutation of the Earth's axis. Both these motions of the terrestrial axis are occasioned by the action of the sun, moon, and planets on the earth.

There are several other astronomical phenomena, that belong to these scientific views of the Earth; but we will give them in their proper places, rather than encumber this article with what is more detached.

The Moon, the Earth's satellite, has motions eccentric and irregular. She performs her sidereal revolution in 27^d 7^h 43′ 11″,5 But this period is variable, and on comparison of the modern observations with the ancients, proves incontestably an acceleration in her mean motion. Her mean tropical revolution is 27^d 7^h 43′ 4″,7; and her mean synodical revolution is 49^d 12^h 42′ 2″,8. Her mean distance from the earth is 29·982175 times the diameter of the terrestrial equator; or above 237,000 miles. Her orbit is inclined to the plane of the ecliptic in an angle of 5° 9′; but this inclination is variable. The greatest inequality, which sometimes extends to 8′ 47″,1, is proportional to the co-sine of the angle on which the inequality of the nodes depends. Her orbit, at the commencement of the present century, crossed the ecliptic in 0s 15° 55′ 26″,3; but the place of her nodes is variable. They have a retrograde motion, and make a sidereal revolution in about 18·6 Julian years. A synodical revolution of the nodes is performed in 346^d 14^h 52′ 43″,6. The motion of the nodes is subject also to a secular inequality, dependent on the acceleration of the Moon's mean motion. The rotation of the Moon on her axis is equal and uniform; and it is performed in the same time as the tropical revolution in her orbit, whence she always presents nearly the same face to the earth. But, as the motion of the Moon in her orbit is periodically variable, we sometimes see more of her eastern edge, and sometimes more of her western edge. This appearance is called the libration of the Moon in longitude. The axis of the Moon is inclined to the plane of the ecliptic in an angle of 88° 29′ 49″. In consequence of this position of the Moon, her poles alternately become visible to, and obscured from us: and this phenomenon is called her libration in latitude. There is also another optical deception, arising from the Moon being seen from the surface of the earth, instead of the centre. This appearance is called her diurnal libration. The figure of the Moon A, B, C, &c. (fig. 113,) is that of an oblate spheroid like the earth T. Her mean diameter is in the proportion to that of the earth, as 5823 to 21332; or, as 1 to 3·665. Whence her mean diameter will be about 2160 miles. But the apparent diameter of the Moon varies according to her distance from the earth. When nearest to us, it is 33′ 31″,1; and at her greatest distance it is 29′ 21″,5. Hence her mean apparent diameter is 31′ 26″,5. The different phases of the Moon constitute some of the most striking phenomena of the heavens. When she emerges from the sun's rays, S, in the evening, she appears as a small crescent, *b*, just visible; but as she separates from the sun this crescent increases, *c*, *d*, till in opposition, *e*, when the moon is completely illuminated. This circle changes reversely into a crescent, *f*, *g*, *h*, till the Moon has plunged into the sun's rays in the morning at sun-rise. And the crescent being always directed to the sun, indicates that the Moon is herself a dark opaque body, borrowing her light from the sun. These different phases, A, B, C, D, &c. of the Moon are renewed after every conjunction; and the points of the lunar orbit, in which the Moon is either in conjunction or opposition to the sun, are called the *syzygies*. In the first point, the Moon is new, in the second full; in her first quarter the Moon is 90° from the first point; in her third quarter 270° from the same point.

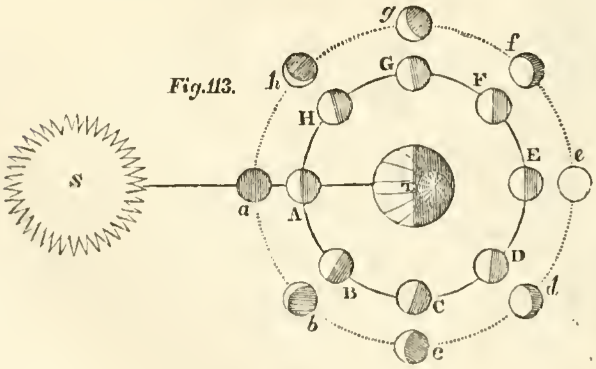
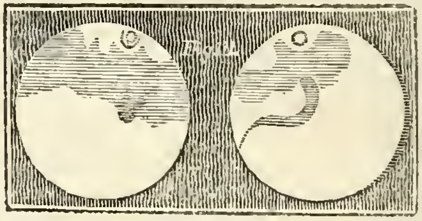


Fig.113.

Mars, ♂, fig. 114.—Mars first above the earth's orbit is easily known by his red and fiery appearance. He performs his sidereal revolution in 686^d 23^h 30′ 39″, or in 1·881 Julian year; and his mean synodical revolution is about 780 days, or in about 2·135 years. His mean distance from the sun is above 142 millions of miles. The rotation on his axis is performed in 1^d 0^h 39′ 21″,3; and his mean diameter is 4398 miles, or rather more than one half the size of our earth. This planet has a very dense but moderate atmosphere, and he is not attended by any satellite. And the proportion of light and heat received by him from the sun is ·43, that received by the earth being considered as unity. Mars changes his phases in the same manner as the moon does, from her first to her third quarter, according to his various positions with respect to the earth and sun.



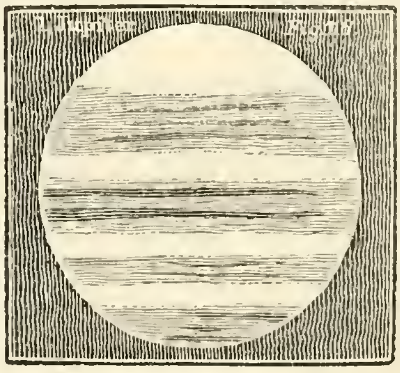
Vesta ⚶.—This planet was discovered by Dr. Olbers, of Bremen, on the 29th of March, 1807: its distance from the sun is 225,435,000 miles, and the length of its year, 3 years 240 days 5 hours. Vesta appears like a star of the fifth magnitude.

Juno ⚵.—Juno was discovered by Mr. Harding, of Lilienthal, in the duchy of Bremen, on the first of September, 1804. It appears like a star of the eighth magnitude: its distance from the sun is 253,380,485 miles, and its periodical revolution is performed in 4 years and 131 days.

Ceres ⚳.—Ceres was discovered by M. Piazzi, astronomer royal, at Palermo, in the island of Sicily, on the 1st of January, 1801. The length of its year is 4 years 221 days 13 hours; its distance from the sun is 262,903,570 miles, and its diameter, according to Dr. Herschel, is about 162 miles. Ceres appears like a star of the eighth magnitude.

Pallas ⚴, was discovered by Olbers on the 28th of March, 1802. Its distance from the sun is 253,000,000 miles. Its annual revolution is completed in about 4 years 7 months and 10 days. Like the two former newly discovered planets, its diameter and diurnal rotation are as yet unknown.

Jupiter, ♃, fig. 116, is about four hundred and eighty-five millions of miles from the sun. It completes its annual revolution in about 12 years, moving at the rate of 29,000 miles an hour. Its diameter is 91,500 miles, yet by an exceedingly rapid motion upon its axis, the diurnal rotation is performed in nine hours and 55 minutes! Notwithstanding the great distance of this fine planet from the sun and the earth, it appears, to the naked eye, almost as large as Venus, though with a less brilliant light. When Jupiter rises as the sun sets, and sets as the sun rises, it comes to the meridian at midnight, and appears larger and more luminous that at other times. It is a morning



star when its longitude is less than that of the sun, and an evening star when the longitude is greater than that of the sun. Jupiter is surrounded by faint substances, called zones or belts, which, from their frequent change in number and situation, are generally supposed to consist of clouds. One or more dark spots frequently appear between the belts; and when a belt disappears, the contiguous spots disappear likewise. The time of the rotation of the different spots is variable, being less by six minutes near the equator than near the poles.

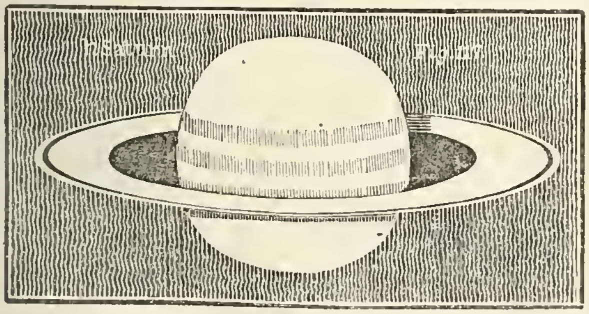
Satellites of Jupiter.—By the aid of the telescope we may discover four satellites revolving round Jupiter. The sidereal revolutions of these bodies are given in the following table: together with their mean distances from Jupiter, the semidiameter of that planet's equator being considered as unity; and likewise their masses, compared with Jupiter, considered also as unity.

TABLE.

Satellite.	Sidereal Revolution.		Mean Distance.	Mass.
I.	1^d 18^h 27′ 33″,5	1^d 769137788148	5·812964	·0000173281
II.	3 13 13 42 ,0	3 551181017849	9·248679	·0000232355
III.	7 3 42 33 ,4	7 154552783970	14·752401	·0000884972
IV.	16 16 31 49 ,7	16 688769707084	25·946860	·0000426591

The satellites of Jupiter are liable to be eclipsed by passing through his shadow; and on the other hand, they are frequently seen to pass over his disk, and eclipse a portion of his surface. This happens to the first and second satellite at every revolution; the third very rarely escapes in each revolution; but the fourth (on account of its great distance and inclination) is seldom obscured. These eclipses are of great utility, in enabling us to determine the longitude of places, by their observation; and they likewise exhibit some curious phenomena with respect to light. From the singular analogy above alluded to, it follows, that, (for a great number of years at least,) the first three satellites cannot be eclipsed at the same time: for in the simultaneous eclipses of the second and third, the first will always be in conjunction with Jupiter, and *vice versâ.*

Saturn, ♄, fig. 117.—Saturn is about eight hundred and ninety millions of miles from the sun. It moves at the rate of 22,000 miles an hour, and performs its annual revolution in a little less than 29½ years. His mean distance from the sun is above 890 millions of miles. The rotation on its axis is performed in 10^h 16′ 19″,2; and the axis is inclined in an angle of 58° 41′ to the plane of the ecliptic. His mean diameter is 76068 miles; consequently he is nearly ten times as large as our earth. The axis of his poles is to his equatorial diameter as 11 to 12. The proportion of light and heat received from the sun is ·0011; that received by the earth being considered as unity. Saturn is sometimes marked by zones or belts, which are probably obscurations in his atmosphere; and he is accompanied by seven satellites. The most singular phenomenon, however, attending this planet, is the double ring with which he is surrounded. This ring, which is very thin and broad, is inclined to the plane of the ecliptic in an angle of 31° 19′ 12″,0; and revolves from west to east, in a period of 10^h 29′ 16″,8, about an axis perpendicular to its plane, and passing through the centre of the planet. The breadth of the ring is nearly equal to its distance from the surface of Saturn; that is, about one-third of the diameter of the planet. The surface of the ring is separated in the middle by a black concentric band, which divides it into two distinct rings. The edge of this ring, being very thin, sometimes disappears; and, as this edge will present itself to the sun twice in each revolution of the planet, it is obvious that the disappearance of the ring will occur about once in 15 years, but under circumstances oftentimes very different. The intersection of the ring and the ecliptic is in 5^s 20° and 11^s 20°; consequently, when Saturn is in either of these signs, his ring will be invisible to us. On the contrary, when he is in 2^s 20° or 8^s 20°, we may see it to most advantage. This was the case towards the end of the year 1811.



Satellites of Saturn.—Seven satellites may be seen, by means of the telescope, to revolve about Saturn; the elements of which are but little known, on account of their great distance. The following table will shew the duration of their sidereal revolutions, and their mean distances in semidiameters of Saturn.

Satellite.	Sidereal Revolution.		Mean Distance.
I.	0^d 22^h 37′ 30″,1	0^d 94271	3·080
II.	1 8 53 8 ,7	1 37024	3·952
III.	1 21 18 25 ,9	1 88780	4·893
IV.	2 17 44 51 ,1	2 73948	6·268
V.	4 12 25 11 ,1	4 51749	8·754
VI.	15 22 41 13 ,9	15 94530	20·295
VII.	79 7 54 37 ,4	79 32960	59·154

The orbit of the first six satellites appear to be in the plane of Saturn's ring; whilst the seventh varies from it very sensibly.

Uranus, or *Herschel*, ♅, called also *Georgium Sidus*, was discovered by Dr. Herschel on the 13th of March, 1781. Its distance from the sun is about one thousand eight hundred millions of miles, and its diameter 35,000. Its annual revolution is completed in about eighty-four years, and its rotary motion in about the same time as Saturn. The appearance of Uranus is that of a star of the sixth magnitude, and therefore it can scarcely be seen without a telescope. The intensity of light or heat, on this distant planet, is to that on the earth as 276 is to 100,000. And the sun's diameter, as seen from Uranus, is about the magnitude of Jupiter's when in opposition.

Satellites of Uranus.—Six satellites revolve round Uranus; which, together with their primary, can be discovered only by the telescope. The following table will shew their sidereal revolutions, and mean distances in semidiameters of the primary.

Satellite.	Sidereal Revolution.		Mean Distance.
I.	5^d 24^h 25′ 20″,6	5^d 8926	13·120
II.	8 16 57 47 ,5	8 7068	17·022
III.	10 23 3 59 ,0	10 9611	19·845
IV.	13 10 56 29 ,8	13 4559	22·752
V.	38 1 48 0 ,0	38 0750	45·507
VI.	107 16 39 56 ,2	407 6944	91·008

All these satellites move in a plane, which is nearly perpendicular to the plane of the planet's orbit, and contrary to the order of the signs.

Of Comets.—Comets are opaque and solid bodies. A Comet, at a given distance from the earth, shines much brighter when it is on the same side of the earth with the sun, than when it is on the contrary side; from whence it appears, that it owes its brightness to the sun. Of all the comets, the periods of only three are known with any degree of certainty. The first of these Comets appeared in the years 1531, 1607, and 1682; and is expected to appear every 75th year. The second of them appeared in 1532 and 1661, and was expected to return in 1789, and every 129th year afterwards. The third having last appeared in 1680, and its period being no less than 575 years, cannot return until the year 2225. This Comet, at its greatest distance, is about eleven thousand two hundred millions of miles from the sun; and at its least distance from the sun's centre, which is 49,000 miles, is within less than a third part of the sun's semidiameter from his surface. In that part of its orbit which is nearest the sun, it moves at the rate of 880,000 miles in an hour. The Chinese astronomers record the appearance of about 300 Comets. The tail of the Comet of 1680 was at least 100 millions of miles long; and that of 1812 was 30 millions of miles. The Comets trace, around the sun, very elongated ellipses, which degenerate into parabolæ. Hence their appearance in our heavens is only momentary, because we can see them in only so small a portion of the curve they describe, though for some it extends to the confines of the solar system. This motion is without fixed direction; the Comets re-act every way, and frequent perturbations make their course devious. Such effect did the re-action of Saturn and Jupiter produce on the comet of 1759. By the action of Jupiter, that of 1770 deviated so much when towards its perihelion, that its orbit became elliptic. On its return, the same effect in a contrary direction caused it to resume its parabolic course. The cause of this luminosity, called the *tail* of a Comet, has been thus described:—

"Suppose a globe of water, with an opaque ball in its centre—in other words, the pellucid atmosphere of a comet and its nucleus—suppose them placed in the sunshine (the situation of a Comet at all times,) is it not then evident that the globe of water, with its opaque ball, would, by the refraction and reflection of rays of light, exhibit all the phenomena of a Comet's tail, under all the circumstances and variations of that tail? By the ordinary laws of refraction, the tail would be lengthened as it approached the sun, and would shorten as it receded, which we know accords with the phenomena.

"The tail of a Comet is thence considered a grand optical exhibition of the phenomena of light. As the solar rays pass in their ordinary course through the medium of space, they exhibit no peculiar appearances; but when they impinge on the atmosphere of a planetary body, they undergo refractions and reflections; then they exhibit their general, visual phenomena, whether it be as condensed in the shape of a Comet's tail, or in giving luminosity to the figure of a planet. As the spherical refracting medium approaches the source of light, the foci of convergency of course are extended, and the quantity of light is increased; and then is the Comet's tail of the largest dimensions, and the most luminous. As it recedes from the fountain of light, the foci draw nearer to the Comet, and the tail shortens; at length the Comet recedes so far from the sun, that the quantity of light ceases to produce the same visual effect, while the increased distance from the earth combines also to render it altogether invisible.

"Telescopes destroy the tail, because they magnify the space without increasing the light, an effect which is universal when they are applied to luminous objects, but more sensible in regard to a Comet's tail than to any other object of telescopic observation; serving, therefore, to prove that it is light itself, rather than any crude vapour on which light is impinging. The stars are seen through it, because they shine by their inherent light, and there is no substance or opacity intercepting their rays.

"Supposing that fluids and solids compose nearly equal parts of Comets, it will not be difficult to explain their varied aspect. The sun's expansive action being null in its aphelion, it exhibits properties analogous to opaque bodies, but less marked, the fluids being adequate to produce a proper light. In this state, the Comet has a solid and opaque nucleus; proportionally greater, from the aqueous vapours condensed from its atmospheres; which last is of a moderate extent.

"How pleasing is the idea of contemplating these travelling worlds, peopled with observers, employed in contemplating the universe at large, as we are busied in that of an insignificant atom of it; passing from one sun to another, observing the orbits of the celestial spheres; viewing their particular and general revolutions; over their heads thousands of years rolling, merely as thousands of days over ours!"

For the laws by which the planets are kept in their respective positions, or whirled with unerring precision round the sun, and amongst one another, see the articles ATTRACTION and LAWS OF PLANETARY MOTION.

The Fixed Stars.—Besides the sun, planets, and comets which we have noticed, as belonging to our system, there are other phenomena that we may observe, as the Fixed Stars, distinguished from the planets, by being less bright, less luminous, and exhibiting continually an appearance, which we call the *twinkling of the stars.* The Fixed Stars are so named from their never changing their situation with regard to each other, as the planets change their places. They are, thence, considered suns of other systems or worlds. How magnificent then is this universe!

1. The Fixed Stars are luminous bodies. Because they appear as points of small magnitude when viewed through a telescope, they must be at such immense distances as to be invisible to the naked eye, if they borrowed their light; as is the case with respect to the satellites of Jupiter and Saturn, although they appear of very distinguishable magnitude through a telescope. Besides, from the weakness of reflected light, there can be no doubt but that the Fixed Stars shine with their own light. They are easily known from the planets by their twinkling.

2. The number of Stars, visible at any one time to the naked eye, is about 1000; but Dr. Herschel, by his skilful improvements of the reflecting telescope, has discovered that the whole number is great beyond all conception. The comparative brightness of the Stars is, Sirius 100, Canopus ·98, Centauri ·96, Achernar ·94.

3. The magnitudes of the Fixed Stars appear to be different from one another, which difference may arise either from a diversity in the real magnitudes, or distances; or from both these causes acting conjointly. The difference in the apparent magnitude of the Stars is such as to admit of their being divided into six classes, the largest being called Stars of the first magnitude, and the least which are visible to the naked eye, Stars of the sixth magnitude. Stars only visible by the help of glasses are called telescopic Stars. Bode's catalogue contains 17,000 Stars. Dr. Halley very justly remarks, that the Stars must be infinite in number, to maintain their equilibrium in space. And Dr. Herschel thinks he has seen Stars 42.000 times as far off as Sirius. In one instance, a cluster of 5000 stars, in a mass, were barely visible in the 40-foot telescope, and consequently must have been 11 trillions of miles off!

4. It must not be inferred, that all the Stars of each class appear exactly of the same magnitude, there being great latitude given in this respect; even those of the first magnitude appear almost all different in lustre and size. There are also other Stars of intermediate magnitudes, which, as astronomers cannot refer to any one class, they, therefore, place them between two; or that, in place of six magnitudes, there are probably as many different magnitudes as there are Stars.

5. To the naked eye, the Stars appear of some sensible magnitude, owing to the glare of light arising from numberless reflections of rays coming to the eye; this leads us to imagine, that the Stars are much larger than they would appear, if we saw them only by the few rays which come directly from them, and entered the eye without being intermixed with others. Examine a Fixed Star of the first magnitude, through a long and narrow tube, which, though it takes in as much of the sky as would hold a thousand such stars, scarcely renders that one visible. Even our best telescopes do not enlarge these gems; and there seems but little reason to expect, that the real magnitudes of the Fixed Stars will ever be discovered with certainty; we must, therefore, be contented with an approximation, deduced from their parallax, and the quantity of light they afford us compared with the sun. To this purpose, Dr. Herschel, with a magnifying power of 6450, and by means of his new micrometer, found the apparent diameter of *α* Lyræ to be 0″·335, or the third of a second.

The ingenious observations of Kepler upon the magnitudes and distances of the Fixed Stars, have been followed by Dr. Halley. He observes, that there can be only 13 points upon the surface of a sphere as far distant from each other as from the centre; and supposing the nearest Fixed Stars to be as far from each other as from the sun, he concludes, that there can be only 13 Stars of the first magnitude. Hence, at twice that distance from the sun, there may be placed four times as many, or 52; at three times that distance, nine times as many, or 117; and so on. These numbers will give pretty nearly the number of stars of the first, second, third, &c. magnitudes. Dr. Halley farther remarks, that if the number of Stars be finite, and occupy only a part of space, the outward stars would be continually attracted to those within, and in time would unite into one. But if the number be infinite, and they occupy an infinite space, all the parts would be nearly in equilibrio, and consequently, each Fixed Star being drawn in opposite directions, would keep its place, or move on till it had found an equilibrium.

A Constellation is a number of Fixed Stars, lying in the neighbourhood of each other, which astronomers, for the sake of remembering with more ease, suppose to be circumscribed by the outline of some animal or other figure. *See* CONSTELLATION.

An Eclipse of the Sun is caused by the moon passing between the sun and the earth; and an Eclipse of the Moon is the effect of the earth passing between the sun and moon. *See* ECLIPSE.

ASTROSCOPE, an astronomical instrument, composed of two cones, on whose surfaces are exhibited the stars and constellations, by means of which they are both easily found in the heavens. This instrument was the invention of Schukhard, professor of mathematics at Tubingen, who published a treatise expressly on it in 1698.

ASTROSCOPIA, is the art of observing and examining the stars with the telescope, in order to discover their nature and properties.

ASTROTHESIA, an ancient term, nearly synonymous with constellation.

ASTRUM, or ASTRON, a constellation or assemblage of stars, the same as Aster denotes a single star.

ASYLUM, a sanctuary, or place of refuge, where criminals shelter themselves from the hands of justice. The *asyla* of altars, temples, tombs, statues, &c. is very ancient. The Jews had six cities of refuge, the temple and the altar of burnt-offering. The temple of Diana, at Ephesus, was a refuge for debtors; hence, when the apostle of our Lord preached salvation to the worst of mankind, it included also the hapless debtor, who would thus be restored to the favour of the Deity; an idea in no ways compatible with the notions of the heathen creditor.—The emperors Honorius and Theodosius granting particular immunities to churches, the bishops and monks laid hold of a certain tract or territory, without which they fixed the bounds of the secular jurisdiction; and so well did they manage their privileges, that convents, in a little time, became next akin to fortresses, where the most notorious villains were in safety, and braved the power of the magistrate.

ASYMETRY, without measure, a want of proportion between the parts of a thing, as between the side and diagonal of a square, which are to each other as $1 : \surd 2$.

ASYMPTOTE, incoincident, is properly a right line, which approaches continually nearer to some curve, whose asymptote it is said to be, in such sort, that when they are both indefinitely produced, they are nearer together than by any assignable finite distance; or it may otherwise be considered as a tangent to the curve, when infinitely produced, or at an infinite distance. Two curves are also said to be asymptotical, when they thus continually approach indefinitely to a coincidence: thus two parabolas placed with their axis in the same right line, are asymptotes to each other. Of lines of the second kind, or curves of the first kind, that is, the conic sections, only the hyperbola has asymptotes, which are two in number. All curves of the second kind have at least one asymptote, but they may have three; and all curves of the third kind may have four asymptotes, and so on. The conchoid, cissoid, and logarithmic curve, though not geometrical curves, have each one asymptote; and the branch or leg of the curve that has an asymptote, is said to be of the hyperbolic kind. The nature of an asymptote is very difficult to be conceived by persons who are not acquainted with the higher geometry: they cannot comprehend how two lines should always continually approach each other, without the possibility of touching or coinciding; this mystery, however, may be elucidated, and the nature of these lines readily comprehended, by considering the generation of the conchoid of Nicomedes, which is as follows. Let F K (fig. 118.) be any line indefinite towards K, and from the point P let there be drawn the lines PA, PB, PC, PD, &c. making the several parts FA, GB, HC, ID, KE, &c. all equal to each other: the curve A B C D E, &c. passing through all the extremities A, B, C, D, &c. is called the conchoid of Nicomedes; and the line F K produced, is the asymptote of the curve; and which, it is obvious from the construction, can never coincide or touch the curve itself, although the latter continually approaches towards the former.

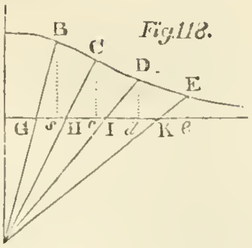


Fig.118.

ATAR OF ROSES, a precious essence, which is easily obtained, provided the material from which it is extracted is supplied in quantities sufficient for the purpose, but unfortunately one hundred weight of roses generally yields but from two to three ounces of Atar. The roses, with their calyxes, are to be immersed in double their weight of water, and distilled by a very gentle heat, from which will be obtained a very strongly scented rose wine. This must be cooled as quickly as possible by the night air, and the globular particles found upon its surface, carefully gathered the next morning, which are more or less abundant, according to the perfection of the roses. A peculiarly fragrant grass is employed in Persia along with the roses, besides other odorous vegetable substances which that rich climate produces; but although the quantity of essence is thereby increased, its quality is deteriorated. Even after the Atar has been gathered, the rose-water that remains is powerfully scented. It is not necessary to distil the roses immediately after they have been gathered, as that may be inconvenient, particularly on account of the heat of the weather when the flower is produced. Rose leaves, as well as other flowers capable of affording fragrant essential oils, may be preserved fer a long period, as in a pot-pourie, without losing any of their odour, or by being well rubbed, and mixed into a paste with common salt. The quantity of oil and water is said to be greatly increased by the salting process, which is indeed probable. The proportion of salt is one pound to three pounds of leaves. The flowers being bruised by the friction of the grains of salt, form a paste, which should be preserved in an earthen jar or barrel; continuing the process uniformly until the barrel or jar is filled, which may be kept in a cool place for several years, without impairing its flavour or strength. This aromatic paste may be distilled at any season of the year, mixing it with about twice its weight of water before you put it into the still. Indeed, in many gardens in Britain a sufficient quantity of rose leaves might be gathered in a couple of years, to verify this recipe for the extraction of Atar of roses. The generality of perfumes are made up of musk, civet, ambergris, cedar, roses, orange flowers, jonquils, jessamines, tuberoses, and other odoriferous flowers and plants; and their use among the Hebrews, and most of the Oriental nations, was common, before they were known to the Greeks and Romans. But as the nervous system is very much affected by the use of these volatile drugs, medical men generally strongly condemn the practice, still so much in fashion, of scenting the clothes, hands, face, &c. with musk, atar of roses, &c.

ATARGATIS, a goddess of the Syrians, represented with the head and breasts of a woman, and the tail of a fish. Both the Syrians and Egyptians abstained from eating fish, which they seem to have held in singular dread and abhorrence, and when the Egyptians had to represent any thing as odious, or to express hatred by hieroglyphics, they painted a fish. A deity of the name of Dagon was worshipped under the form of a monster, which had the head and arms of a man, and the tail of a fish. This appears to have been the symbol of the sun in Pisces, and was considered as the principle of fecundity; hence Dagon seems to have been employed to signify the "corn and fruits of the earth." No sign appears to have been considered of more malignant influence than Pisces. The astrological calendar describes the emblems accompanying this constellation as chiefly indicative of violence and death; yet the month of February, when the sun was in Pisces, was called Adar; perhaps in honour of the moon, which was adored by the title Adra Daga, or the, "glorious fish."

ATCHIEVEMENT, or Achievement, in Heraldry, the arms of a person or family, marshalled in order; with quarterings by alliance, mottos, scrolls, crest, mantle, helmet, &c.

ATHAMANTA, spignel.

ATHANASIA, goldilocks.

ATHANASIAN Creed, the exposition of faith composed by Hilary, bishop of Arles, about the year 430, and which was received at Rome about the year 1014, as a summary of the orthodox faith, and a condemnation of all heresies.

ATHWART, in Navigation, across the line of the course; *athwart the forefoot*, the direction of a cannon ball from one ship across another, to intercept the latter, and oblige her to shorten sail, and heave to, that the former may come near enough and examine her. *Athwart hause*, the situation of a ship when she is driven by wind or tide, or any other accident, across the fore part of another ship.

ATLAS, in matters of literature, a book of maps, either celestial, as Dr. Jamieson's atlas; or terrestrial, as Arrowsmith's atlas.

ATRIPLEX, orach, or arach.

ATROPA, deadly nightshade, whose horrid black berries and root are the rankest poisons.

ATTACHMENT, in Law, the apprehending of a person by virtue of a writ. An attachment is issued out of a higher court than a writ, and may lie against the body and goods.

ATTAINDER, in Law, the immediate inseparable consequence of sentence of death being pronounced upon a criminal: or when a person flees from justice, which is tacitly confessing his guilt, the judgment of outlawry is the attainder, for the person is stained, *attinctus*, or blackened, by his own act.

ATTITUDE, in Painting and Sculpture, the gesture of a figure or statue; or such a disposition of their parts as serves to express the action and sentiments of the person represented.

ATTORNEY at Law, one put in the place of another person, to manage his matters in law. The attorneys are a regular corps, admitted to the execution of their duties by the superior courts of Westminster Hall, and are in all points officers of the respective courts into which they are admitted. The Attorney-general, a great officer appointed by the king's letters patent, prosecutes for the crown in matters criminal. His proper place in court is under the judges, on the left of their clerk: usually, however, he sits within the bar in front of the court.

ATTRACTION, the tendency which all bodies have to approach each other, is distinguished into the attraction of cohesion, and the attraction of gravitation. The attraction of cohesion takes place between bodies, only when they are at very small distances from each other. By this attraction, possessed by the minute parts of matter, bodies preserve their form, and are prevented from falling to pieces. To prove the attraction of cohesion, take two pieces of lead with flat surfaces; scrape them clean with a knife, squeeze them together, and they will adhere so firmly as to be separated with difficulty. And if you wet two bits of glass with water, they also will adhere firmly. Two globules of quicksilver placed near each other, will run together, and become one drop or ball.

A Table of cohesive Powers of different Solids.—To estimate the absolute cohesion of solid bodies, Professor Musschenbroeck, applied weights to separate them according to their length. The pieces of wood he used were parallelopipedons, whose side was $\frac{27}{100}$ths of an inch. The metal wires used were $\frac{1}{10}$th of a Rhinland inch in diameter. They were drawn asunder by the following weights:

	lbs.		lbs.
Fir	100	Copper	299¼
Elm	950	Brass	360
Alder	1000	Gold	500
Oak	1150	Iron	450
Beech	1250	Silver	370
Ash	1250	Tin	49¼
Lead	29¼		

Capillary Attraction—is accounted a species of cohesion. It is called capillary, from the tubes which draw the water above its level being small as hairs. And the suspension of fluids in capillary tubes is owing to the attraction of the ring contiguous to the upper surface of the fluid. The height to which the fluid rises is inversely as the diameter of the bore. *Experiments:* Take a small glass tube open at both ends, dip it in water, and the water will rise in the tube higher than its level in the basin: the water will rise the higher, the smaller the bore of the tube is. Take two pieces of glass, five or six inches square, join any two of their sides, separate the opposite sides with a small piece of wood, so that the surface may form a small opening, and immerse them about an inch deep in a basin of coloured water: then the water will rise between the glasses, and form a very beautiful curve. Upon the same principle it is that a piece of sugar, or a sponge, draws up water or any other fluid. All vegetables are but bundles of capillary tubes; and whether we consider earth, water, salt, and oil, as the food of plants, that food must be formed by water into an emulsion, capable of being acted upon by capillary attraction; unless we suppose the juice, or food, to rise in those tubes by some law of hydraulics. As all the roots are but assemblages of these tubes, there can be little doubt but their attraction supplies the plant or tree with its first food; though other causes, no doubt, assist in carrying it to the tops of the tallest trees, such as dilatation and contraction, by the successive heat and cold of day and night; the muscular action of vascular rings round the tubes, irritated to contraction by the stimulant sap, &c. The interior bark conducts the nourishment supplied by the earth. Leaves on one side draw nutrition also from the air, and perspire on the other; light probably does the rest. It is probably owing to the various degrees of cohesion, that some bodies are hard and others soft; that some are in a solid, others in a fluid state. For when attraction prevails in bodies, they become solid; when fire prevails, they become gas; hence fluidity seems a medium between both. As it is by the attraction of cohesion that the parts of bodies are kept together, this attraction is overcome when a body is broken. Hence the reason of soldering metals, gluing wood, &c. Hence, also, when the particles, or moleculæ, of which a body is composed, so adhere the one to the other, that they cannot be separated without effort, we say of such a body that it is solid;—such are metals, stone, wood, &c. Hence, also, such substances as are composed of particles adhering very slightly, and which, yielding to any small effort, are easily moved among each other, we term fluids, such as water, beer, air, &c. These properties may result from the different figures of the particles, and the greater or less degree of attraction thereupon. Elasticity may arise from the particles of a body, when distended, not being amply drawn into each other's attraction; as soon, therefore, as the force which acts upon it ceases, they restore themselves to their former position. Density, strictly speaking, denotes the closeness of particles, and we use the word here as a term of comparison, expressing the proportion or quantity of matter in one body, to the quantity in another. Repulsion is a force supposed to extend to a small distance round bodies, and prevent them from coming in actual contact. The repelling force of the particles of a fluid is small, and therefore, if a fluid be divided, it readily unites again. But if a hard substance be broken, the parts cannot be made to adhere, unless they be moistened or melted according to their nature. Water repels most bodies till they are wet. A small sewing needle will swim in a basin of water. Drops of water will roll on the leaves of many vegetables without wetting them. If a ball of light wood be dipped in oil, and afterwards dropped into water, the water will be repelled from the wood, and will form a channel round it. Density, therefore, is directly as the quantity of matter, and inversely as the magnitude of the body.

The Attraction of Gravitation.—Gravity is that force by which all the masses of matter tend towards each other, and which they exert at all distances. It is by this attraction that the heavenly bodies are retained in their several places, by their action on each other, and it is also by this that a stone dropped from a height falls to the surface of the earth. It is one of the laws of nature, that every particle of matter gravitates towards every other particle. The planets and comets all gravitate towards the sun, and towards each other, as well as the sun towards them, and that in proportion to the quantity of matter in each. All terrestrial bodies tend towards the centre of the earth, consequently bodies fall every where perpendicular to its surface, and on opposite sides in opposite directions. As gravity acts upon all bodies in proportion to their quantities of matter, it is this attractive force that constitutes their weight. In all places equidistant from the centre of the globe, the force of gravity is equal. The force of gravity is greatest at the earth's surface, from whence it decreases both upwards and downwards. Upwards the force decreases as the square of the distance from the centre increases; but below the surface of the earth the force of gravity decreases, so that at the distance of half a semidiameter from the centre, it is but half what it is at the surface; at one-third of the semidiameter, one-third; and so on for any other assumed distances. Gravity and weight are, in particular circumstances, synonymous terms. We say such a piece of lead weighs a pound, but if by any means it could be carried 4000 miles above the surface of the earth, it would only weigh four ounces; and provided it could be removed 8000 miles above the earth, which is three times the distance from the centre that the surface is, it would weigh only one-ninth of a pound. Again, since the force of gravity downwards decreases as the distance from the surface increases, 16 ounces would weigh, at one-half the distance from the centre to the surface, only eight ounces, and so on for one-third, &c. Hence, a piece of metal, &c. weighing on the surface of the earth one pound, will

At the centre weigh	0
1,000 miles from the centre	$\frac{1}{4}$ of a pound.
2,000	$\frac{1}{2}$
3,000	$\frac{3}{4}$
4,000	1
8,000	$\frac{1}{4}$
12,000	$\frac{1}{9}$

ATTRIBUTES, in Theology, the several qualities or perfections of the Divine nature: in Logic, the predicates of any subject, or what may be affirmed or denied of any thing: in Painting and Sculpture, symbols added to several figures, to intimate their particular office and character. Thus, the *eagle* is an attribute of Jupiter; the *peacock*, of Juno; a *club*, of Hercules; a *trident*, and chariot with sea-horses, of Neptune; of Hope, an anchor; of Faith, a cross; &c.

ATWOOD'S MACHINE, (figure 119,) illustrates the doctrines of accelerated motion, by subjecting to experimental examination the quantity of matter moved, the measure of the force which moves it, the space described from quiescence, the time of description, and the velocity acquired. The theory of this instrument depends upon principles usually exhibited in dynamics.

1. *Of the Mass moved.*—In order to observe the effects of the moving force, which is the object of any experiment, the interference of all other forces should be prevented: the quantity of matter moved, therefore, considering it before any impelling force has been applied, should be without weight; for although it be impossible to abstract the natural gravity or weight from any substance whatever, yet the weight may be so counteracted as to be of no sensible effect in experiments. Thus, in the instrument constructed to illustrate this subject experimentally, A B represent two equal weights affixed to the extremities of a very fine and flexible silk line: this line is stretched over a wheel or fixed pulley *a b c d*, moveable round an horizontal axis: the two weights, A B, being precisely equal and acting against each other, remain in equilibrio; and when the least weight is superadded to either, (setting aside the effects of friction,) it will preponderate. When A B are set in motion by the action of any weight m, the sum $A+B+m$ would constitute the whole mass moved, but for the inertia of the materials which must necessarily be used in the communication of motion: these materials consist of, 1. The wheel *a b c d*, over which the line sustaining A and B passes. 2. The four friction wheels, on which the axle of the wheel *a b c d* rests: the use of these wheels is to prevent the loss of motion, which would be occasioned by the friction of the axle, if it revolved on an immoveable surface. 4. The line by which the bodies A and B are connected, so as when set in motion to move with equal velocities. The weight and inertia of the line are too small to have sensible effect on the experiments; but the inertia of the other materials just mentioned constitutes a considerable proportion of the mass moved, and must be taken into account. Since, when A and B are put in motion, they must necessarily move with a velocity equal to that of the circumference of the wheel *a b c d*, to which the line is applied; it follows, that if the whole mass of the wheels were accumulated in this circumference, its inertia would be truly estimated by the quantity of matter moved: but since the parts of the wheels move with different velocities, their effects in resisting the communication of motion to A and B by their inertia will be different; those parts which are furthest from the axis resisting more than those which revolve nearer, in a duplicate proportion of those distances. If the figures of the wheels were regular, from knowing their weights and figures, the distances of their centres of gyration from their axes of motion would become known, and consequently an equivalent weight, which being accumulated uniformly in the circumference *a b c d*, would exert an inertia equal to that of the wheels in their constructed form. But as the figures are wholly irregular, recourse must be had to experiment, to assign that equivalent quantity of matter, which being accumulated uniformly in the circumference of the wheel *a b c d*, would resist the communication of motion to A in the same manner as the wheels. In order to ascertain the inertia of the wheel *a b c d* with that of the friction-wheels, the weights A B being removed, the following experiment was made: A weight of thirty grains was affixed to a silk line, (the weight of which was not so much as $\frac{1}{4}$th of a grain, and consequently too inconsiderable to have sensible effect in the experiment;) this line being wound about the wheel *a b c d*, the weight 30 grains by descending from rest communicated motion to the wheel, and by many trials was observed to describe a space of about $38\frac{1}{2}$ inches in 3 seconds. From these data the equivalent mass or inertia of the wheels will be known from this rule: Let a weight, P, (fig. 120,) be applied to communicate motion to a system of bodies by means of a very slender and flexible line going round the wheel S L D I M, through the centre of which the axis passes, (G being the common centre of gravity, R the centre of gravity of the matter contained in this line, and O the centre of oscillation.) Let this weight descend from rest through any convenient space s inches, and let the observed time of its descent be t seconds; then if l be the space through which bodies descend freely by gravity in one second, the equivalent weight sought $= \frac{W \times SR \times SO}{SD^2} = \frac{P \times t^2 l}{s} - P$. Here we have $p = 30$ grains, $t = 3$ seconds,

Fig.119.

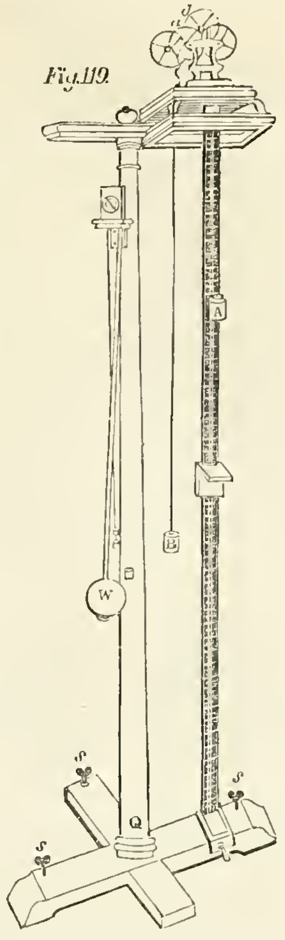
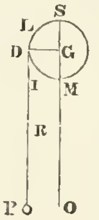


Fig.120.



$l = 193$ inches, $s = 38{\cdot}5$ inches; and $\frac{P \times t^2 l}{s} - P = \frac{30 \times 9 \times 193}{385} - 30 = 1323$ grains, or $2\frac{3}{4}$ ounces. This is the inertia equivalent to that of the wheel *a b c d*, and the friction-wheels together; for the rule extends to the estimation of the inertia of the mass contained in all the wheels. The resistance to motion, therefore, arising from the wheels' inertia, will be the same as if they were absolutely removed, and a mass of $2\frac{3}{4}$ ounces were uniformly accumulated in the circumference of the wheel *a b c d*. This being premised, let the boxes A and B, fig. 119, be replaced, being suspended by the silk line over the wheel or pulley *a b c d*, and balancing each other: suppose that any weight *m* be added to A, so that it shall descend, the exact quantity of matter moved, during the descent of the weight A, will be ascertained, for the whole mass will be $A + B + m + 2\frac{3}{4}$ oz.

In order to avoid troublesome computations in adjusting the quantities of matter moved and the moving forces, some determinate weight of convenient magnitude may be assumed as a standard, to which all the others are referred. This standard weight in the subsequent experiments is $\frac{1}{4}$ of an ounce, and is represented by the letter *m*. The inertia of the wheels being therefore $= 2\frac{3}{4}$ ounces, will be denoted by $11\,m$. A and B are two boxes, constructed so as to contain different quantities of matter, according as the experiment may require them to be varied; the weight of each box, including the hook to which it is suspended, $= 1\frac{1}{2}$ oz., or according to the preceding estimation, the weight of each box will be denoted by $6\,m$; these boxes contain such weights as are represented by fig. 122, each of which weighs an ounce, so as to be equivalent to $4\,m$; other weights of $\frac{1}{2}$ oz. $= 2\,m$, $\frac{1}{4} = m$, and aliquot parts of *m*, such as $\frac{1}{2}$, $\frac{1}{4}\,m$, may be also included in the boxes, according to the conditions of the different experiments hereafter described.

Fig. 123.

Fig. 122.

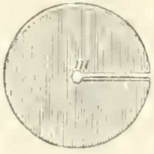


Fig. 121.

If $4\frac{3}{4}$ oz. or $19m$, be included in either box, this, with the weight of the box itself, will be $25\,m$; so that when the weights A and B, each being $25\,m$, are balanced in the manner above represented, their whole mass will be $50\,m$, which being added to the inertia of the wheels $11\,m$, the sum will be $61\,m$. Moreover, three circular weights, such as that which is represented at fig. 122, are constructed; each of which $= \frac{1}{4}$ oz. or *m*: if one of these be added to A and one to B, the whole mass will now become $63\,m$, perfectly in equilibrio, and moveable by the least weight added to either, (setting aside the effects of friction,) in the same manner precisely as if the same weight or force were applied to communicate motion to the mass $63\,m$, existing in free space and without gravity.

2. *The moving Force.* Since the natural weight or gravity of any given substance is constant, and the exact quantity of it easily estimated, it will be convenient here to apply a weight to the mass A as a moving force: thus, when the system consists of a mass $= 63\,m$, according to the preceding description, the whole being perfectly balanced, let a weight $\frac{1}{4}$ oz. or *m*, such as is represented in fig. 123, be applied on the mass A; this will communicate motion to the whole system: by adding a quantity of matter *m* to the former mass $63\,m$, the whole quantity of matter moved will now become $64\,m$; and the moving force being $= m$, this will give the force which accelerates the descent of $A = \frac{m}{64\,m}$, or $\frac{1}{64}$ part of the accelerating force by which the bodies descend freely towards the earth's surface.

By the preceding construction, the moving force may be altered without altering the mass moved; for, suppose the three weights *m*, two of which are placed on A, and one on B, to be removed, then will A balance B. If the weights $3\,m$ be all placed on A, the moving force will now become $3\,m$, and the mass moved $64\,m$ as before, and the force which accelerates the descent of $A = \frac{3\,m}{64\,m} = \frac{3}{64}$ parts of the force by which gravity accelerates bodies in their free descent to the surface. Suppose it were required to make the moving force $2\,m$, the mass moved continuing the same. In order to effect this, let the three weights, each of which $= m$, be removed; A and B will balance each other; and the whole mass will be $61\,m$: let $\frac{1}{2}\,m$ fig. 123, be added to A, and $\frac{1}{2}\,m$ to B, the equilibrium will still be preserved, and the mass moved will be $62\,m$; now let $2\,m$ be added to A, the moving force will be $2\,m$, and the mass moved $64\,m$ as before; wherefore the force of acceleration $= \frac{1}{32}$ part of the acceleration of gravity. These alterations in the moving force may be made with great ease and convenience in the more obvious and elementary experiments, there being no necessity for altering the contents of the boxes A and B; but the proportion and absolute quantities of the moving force and mass moved may be of any assigned magnitude, according to the conditions of the proposition to be illustrated.

3. *Of the Space described.*—The body A, fig. 119, descends in a vertical line; and a scale about 64 inches in length graduated into inches and tenths of an inch is adjusted vertically, and so placed that the descending weight A may fall in the middle of a square stage, fixed to receive it at the end of the descent: the beginning of the descent is estimated from o on the scale, when the bottom of the box A is on a level with o. The descent of A is terminated when the bottom of the box strikes the stage, which may be fixed at different distances from the point o; so that by altering the position of the stage, the space described from quiescence may be of any given magnitude less than 64 inches.

4. *The Time of motion*, is observed by the beats of a pendulum, which vibrates seconds; and the experiments, intended to illustrate the elementary propositions, may be easily so constructed, that the time of motion shall be a whole number of seconds: the estimation of the time, therefore, admits of considerable exactness, provided the observer takes care to let the bottom of the box A begin its descent precisely at any beat of the pendulum; then the coincidence of the stroke of the box against the stage, and the beat of the pendulum at the end of the time of motion, will shew how nearly the experiment and the theory agree together. There might be various mechanical devices thought of for letting the weight A begin its descent at the instant of a beat of the pendulum W: let the bottom of the box A, when at o on the scale, rest on a flat rod, held in the hand horizontally, its extremity being coincident with o; by attending to the beats of the pendulum, and with a little practice, the rod which supports the box A may be removed at the moment the pendulum beats, so that the descent of A shall commence at the same instant.

5. *Of the Velocity acquired.*—It remains only to describe in what manner the velocity acquired by the descending weight A, at any given point of the space through which it has descended, is made evident to the senses. The velocity of A's descent being continually accelerated, will be the same in no two points of the space described. This is occasioned by the constant action of the moving force; and since the velocity of A at any instant is measured by the space which would be described by it, moving uniformly for a given time with the velocity it had acquired at that instant, this measure cannot be experimentally obtained, except by removing the force by which the descending body's acceleration was caused. In order to shew in what manner this is affected practically, let us again suppose the boxes A and $B = 25\,m$ each, so as together to be $= 50\,m$; now let *m*, fig. 121, be added to A, and an equal weight *m* to B, these bodies will balance each other, and the whole mass will be $63m$. If a weight *m* be added to A, motion will be communicated, the moving force being *m*, and the mass moved $64m$. In estimating the moving force, the circular weight $= m$ was made use of as a moving force: but for the present purpose of shewing the velocity acquired, it will be convenient to use a flat rod, the weight of which is also $= m$. Let the bottom of the box A be placed on a level with o on the scale, the whole mass being as described above $= 63\,m$, perfectly balanced in equilibrio. Now let the rod, the weight of which $= m$, be placed on the upper surface of A; this body will descend along the scale precisely in the same manner as when the moving force was applied in the form of a circular weight. Suppose the mass A, (fig. 121.) to have descended by

constant acceleration of force of m, for any given time, or through a given space: let a circular frame be so affixed to the scale, contiguous to which the weight descends, that A may pass centrally through it, and that this circular frame may intercept the rod m, by which the body A has been accelerated from quiescence. After the moving force m has been intercepted at the end of the given space or time, there will be no force operating on any part of the system, which can accelerate or retard its motion: this being the case, the weight A, the instant after m has been removed, must proceed uniformly with the velocity which it had acquired that instant: in the subsequent part of its descent, the velocity being uniform, will be measured by the space described in any convenient number of seconds. Among other uses of the instrument, is the experimental estimation of the velocities communicated by the impact of bodies elastic and non-elastic; the quantity of resistance opposed by fluids, as well as for various other purposes. The properties of retarded motion are a part of the present subject, and may be necessary to shew in what manner the motion of bodies resisted by constant forces are reduced to experiment by means of the instrument above described, with as great ease and precision as the properties of bodies uniformly accelerated. A single instance will be sufficient: Thus, suppose the mass contained in the weights A and B, fig. 121, and the wheels to be $61m$, when perfectly in equilibrio; let a circular weight m be applied to B, and let two long weights or rods, each $= m$, be applied to A, then will A descend by the action of the moving force m, the mass moved being $64\,m$: suppose that when it has described any given space by constant acceleration, the two rods m are intercepted by the circular frame above described, while A, is descending through it, the velocity acquired by that descent is known; & when the two rods are intercepted, the weight will begin to move on with the velocity acquired, being now retarded by the constant force m; and since the mass moved is $62\,m$, it follows that the force of retardation will be $\frac{1}{62}$ part of that force whereby gravity retards bodies thrown perpendicularly upwards. The weight A will therefore proceed along the graduated scale in its descent with an uniformly retarded motion, and the space described. times of motion, and velocities destroyed by the resisting force, will be subject to the same measures as in the examples of accelerated motion above described. In the foregoing descriptions, two suppositions have been assumed, neither of which is mathematically true: but it may be easily shewn that they are so in a physical sense; the errors occasioned by them in practice being insensible.

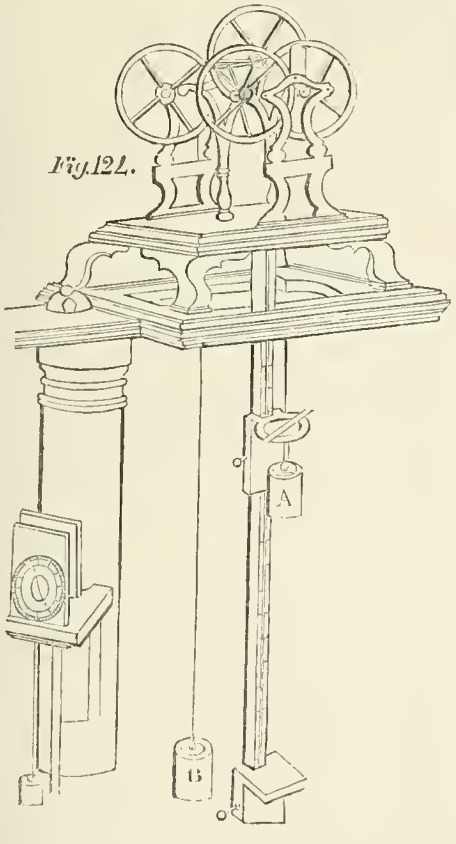


Fig.121.

1. The force which communicates motion to the system has been assumed constant; which will be true only on a supposition that the line, at the extremities of which the weights A and B, fig. 119, are affixed, is without weight. In order to make it evident that the line's weight and inertia are of no sensible effect, let a case be referred to, wherein the body A descends through 48 inches from rest by the action of the moving force m, when the mass moved is $64m$; the time wherein A describes 48 inches is increased by the effects of the line's weight by no more than $\frac{312}{10000}$th parts of a second; the time of descent being 3·9896 seconds, when the string's weight is not considered, and the time when the string's weight is taken into account = 4·0208 seconds; the difference between which is wholly insensible by observation.

2. The bodies have also been supposed to move in vacuo, whereas the air's resistance will have some effect in retarding their motion: but as the greatest velocity communicated in these experiments cannot much exceed that of about 26 inches in a second, (suppose the limit 26·2845,) and the cylindrical boxes being about $1\frac{3}{4}$ inches in diameter, the air's resistance can never increase the time of descent in so great proportion as that of 240 : 241; its effects therefore will be insensible in experiment. The effects of friction are almost wholly removed by the friction-wheels; for when the surfaces are well polished and free from dust, &c. if the weights A and B be balanced in perfect equilibrio, and the whole mass consists of $63\,m$, according to the example already described, a weight of $1\frac{1}{2}$ grain, or at most 2 grains, being added either to A or B, will communicate motion to the whole; which shews that the effects of friction will not be so great as a weight of $1\frac{1}{2}$ or 2 grains. In some cases, however, especially in experiments relating to retarded motion, the effects of friction become sensible; but may be very readily and exactly removed by adding a small weight of 1·5 or 2 grains to the descending body, taking care that the weight added is such as is in the least degree smaller than that which is just sufficient to set the whole in motion, when A and B are equal, and balance each other before the moving force is applied.—The foregoing article is taken nearly verbatim from Dr. Gregory's Mechanics; and the instrument may be purchased for £28, at Harris's, 50, High Holborn.

AUGUST, the eighth month of the year, when we have in season—of Meat: beef, mutton, veal, lamb, buck, venison, &c. Poultry: pullets, fowls, chickens, green geese, turkey poults, ducklings, leverets, rabbits, pigeons, pheasants, wild ducks, wheatears, plovers. Fish: cod, haddock, flounders, plaice, skate, thornback, mullets, mackarel, herrings, pike, carp, eels, lobsters, crawfish, prawns, oysters. Vegetables: carrots, turnips, potatoes, radishes, onions, garlic, shalots, scorzonera, salsific, peas, beans, kidney beans, mushrooms, artichokes, cabbages, cauliflowers, sprouts, beets, celery, endive, pinocha, parsley, lettuce, salads, thyme, marjoram, sweet herbs, savoy. Fruit: peaches, nectarines, plums, cherries, apples, pears, grapes, figs, filberts, mulberries, strawberries, gooseberries, currants, melons, pineapples.

The Botanical Kalendar for August.—Many seeds and herbaceous vegetables ripen in this month, and most of the culinary crops raised in the open garden, are now in perfection. Insects, especially the winged tribes of butterflies, abound, and the gardener should destroy them, or collect them for specimens. Numbers of beautiful insects may thus be gathered, even while at work. The young martins begin to congregate; bees kill their drones; numerous birds resume their spring notes; the goatsuckers and young owls hoop and make a noise in the evenings. Melilot, yellow succory, burdock, tobacco, wild clary, meadow rice, plowman's spikenard, mallows, hollyhocks, lobelias, crocuses, &c. are in flower. Bread corns ripen, and the earlier varieties of all the kernel fruits ripen. Sow turnips for a main crop early in this month, salads, radishes, parsley, spinage, carrots, endive, chervil, for winter and spring crops; cauliflowers to stand over winter, in sheltered borders and under frames. Propagate by slips and cuttings; transplant leeks and perennials; hoe, thin, weed, and stir winter crops; clear off all crops the moment they are done with; gather pickling cucumbers and ripe seeds. Plant strawberries; prune, regulate, and train summer shoots of wall trees and espaliers. Mat up all fruits on north walls, intended to be preserved till late in autumn. Gather gooseberries, currants, and all ripe fruit. Plant evergreens, repair lawns, destroy ferns, nettles, and weeds about park scenery and fences. Take up bulbs, transplant biennials, &c.

AULA Regis, a court established by William the Conqueror, in his own hall, and composed of the great officers of state. The 11th article of Magna Charta regulates this court, which is now established in Westminster Hall. *See* King's Bench.

AULIC Council, composed of the great officers of the German empire, always follows the emperor's court, but ceases on his death; whereas the imperial chamber of assize is perpetual, and represents not only the deceased emperor, but the whole Germanic body. Aulic, in the Sorbonne, &c. is an act which a young divine maintains, upon being admitted a doctor of divinity. It commences by an harangue of the chancellor, addressed to the young doctor, after which he receives the cap, and presides at the aulic or disputation.

AURIGA, in Astronomy, the Waggoner or Charioteer, a mere type or scientific symbol of that beautiful fable which is given us of Phaeton; or, more properly, he may be the attendant of Phœbus at that remote period when Taurus opened the year. The boundaries and contents of this constellation are these:—North by Camelopardalis, east by Lynx, Herschel's Telescope, and Gemini; south by Taurus, and west by Perseus. Auriga contains 66 stars, one of the 1st magnitude, two of the 2d magnitude, nine of the fourth, &c. The declination generally is 45° north, and its right ascension 75°. A large portion of this constellation is always above the horizon to the British isles, and consequently to all places in corresponding latitudes. The Charioteer's head passes vertically over England and Ireland. The most remarkable star in this constellation, and indeed in this quarter of the firmament, is Capella, of the 1st magnitude, situated on Auriga's left, or western shoulder; its north declination is 45° 47′ 18″, and its right ascension 75° 51′ 3″, or 5 hours 3 minutes in time. Capella culminates for the first day of each month in the year, as follows; and by adding 12 hours to the culminating of this or any other star, we determine the time it is on the meridian under the pole. Meridian altitude, 84° 16′ 18″ north.

Month.	Culm.	Month.	Culm.	Month.	Culm.
	ho. mi.		ho. mi.		ho. mi.
Jan.	10 15 A.	May	2 45 A.	Sept.	6 15 M.
Feb.	8 8 A.	June	12 55 A.	Oct.	4 22 M.
March	6 20 A.	July	10 20 M.	Nov.	2 30 M.
April	4 30 A.	Aug.	8 15 M.	Dec.	12 30 M.

AURORA BOREALIS, or *Northern Twilights*, or streamers, may be defined an electrical phenomena, or aërial electricity, which is seen generally in the winter time, and in frosty weather and clear evenings, in the Hyperborean regions of the skies. This meteor assumes every variety of tint that embellishes the iris or rainbow, but wears generally a fiery and purple hue. Its appearance is indeed now so generally known, even in this country, that a more particular description is not requisite: but it may be just observed, that as we only see the extremities of this brilliant phenomenon, we can have but a faint idea of its real splendour in the arctic regions, where it appears in perfection, and proves a great solace to the inhabitants amidst the gloom of the long winter nights. In some parts of Siberia, particularly, this beautiful meteor is constantly exhibited from October to Christmas, and its radiating beams in those parts are remarkably bright.

Captain Ellis, who wintered on the western coast of Hudson's Bay in North America, observes, that no sooner does the sun disappear in those regions, than the aurora borealis diffuses a thousand different lights and colours over the whole concavity of heaven, with such resplendent beauty, that even the full moon cannot eclipse their lustre. It was for a long time a matter of doubt whether this meteor made its appearance in the southern hemisphere; but Mr. Foster, who went round the world with Captain Cook, ascertained the fact, Feb. 17, 1773, in lat. 58° south, though it appeared with phenomena somewhat different from ours. Concerning the cause of the aurora borealis, many conjectures have been formed; but that which seems to be supported by the most specious reasoning ascribes its origin to electricity. It is supposed, that most of the extraordinary meteors and appearances in the skies, related as prodigies by historians, *e. g.* battles, and the like, may be probably enough reduced to the class of *auroræ boreales.* In certain states of the atmosphere these phenomena have sometimes assumed the colour of blood, and made a dreadful appearance. At these times the rustic sages became prophetic, and terrified the gazing spectators with the dread of wars, pestilence, and famine: even persons more enlightened supposed them to be portentous of great events, and timid imaginations shaped them into aërial conflicts.

Captain Franklin enumerates auroa Borealis, at one time, in form of a bright arch, extending across the zenith, in a north-west and south-east direction,—at another, it was extremely brilliant, its coruscations darting at times over the whole sky, and assuming various prismatic colours, of which violet and yellow were predominant,—again, its appearances were greatly diversified, and its motion extremely rapid, its coruscations occasionally concealed stars of the first magnitude in passing over them; once a stream of light illumined the under surface of some clouds as it passed along:—these appearances were visible in the winter. In the spring the aurora was very brilliant and variable; at one time exhibiting illumined beams issuing from the horizon in the north, east, and west points, and directed towards the zenith; in a few seconds these disappeared, and a complete circle was displayed, bounding the horizon at an elevation of 15°. There was a quick lateral motion, in the attenuated beams of which this zone was composed. Its colour was pale yellow, with an occasional tinge of red. On another occasion, the aurora borealis appeared from north-west to south-east, in an arch across the zenith, which afterwards gave place to a beautiful corona borealis.

In the month of Jan. 1821, the aurora appeared with more or less brilliancy on 28 nights, and for many days together the resplendent moon whirled in circles round the heavens, shining with undiminished lustre, and scarcely disappearing below the horizon during the twenty-four hours.

But Captains Franklin and Parry, and Dr. Richardson, who have added to our already accumulated facts relative to this curious phenomenon, have thrown no light on its theory. Now it is known that the luminous beams of this meteor are all cylindrical, and, over a certain extent of country, parallel to one another. And if these cylindrical beams are magnetic, and parallel to the dipping needle at the places over which they appear, then is the aurora borealis a purely magnetic phenomenon, whose beams are governed by the earth's magnetism. And this is the more probable, as the distance of these beams from the earth is nearly equal to their length; the rainbow-like arches being about 150 miles above the earth's surface.

Lieutenant Back, the brave companion of Captain Franklin, relates that, in the same journey to the Polar sea, he imagined more than once, whilst listening attentively in the silence of midnight on the wilds of the American lakes, and gazing on the fantastic beauties of the aurora borealis, he heard a rustling noise, like that of autumnal leaves stirred by the wind. This, however, he thinks was but illusion. The aurora was very sluggish and dim, otherwise he has little doubt he should have ascertained this yet undecided fact. One of the partners of the North West company affirmed, however, that on one occasion amidst these solitudes, he saw the coruscations of the aurora so vivid and low, that the Canadians fell on their faces, fearing they should be killed: he himself threw away his gun and his knife, that he might not attract the flashes, which were within two feet of the earth, flitting along with incredible swiftness, and moving parallel to its surface, making a loud rustling noise like the waving of a flag in a strong breeze. On another occasion these lights rose about north-west, divided into three bars, diverging at equal distances, as far as the zenith, and then converging till they met in the opposite horizon; there were some flashes emitted at right angles to the bars. At another time the coruscations were so bright as to discover eight wolves prowling about the voyagers. Heavy storms were at some places generally anticipated by the activity of the aurora borealis; though not invariably so in other parts of the country.

And analogous to this are those luminous arches so beautifully described by Thomson as

—— Silent from the north
A blaze of meteors shoots; ensweeping first
The lower skies, they all at once converge
High to the crown of heaven, and all at once
Relapsing quick, as quickly reascend,
And mix, and thwart, extinguish and renew,
All ether coursing in a maze of light.

In March, 1774, a very beautiful luminous arch was seen at Buxton. It was white, inclining to yellow; and its breadth in the crown apparently equal to that of the rainbow. As it approached the horizon, each leg became gradually broader. It was stationary, and free from any sensible coruscations. Its direction was from north-east to south-west; and its crown or most elevated part not far from the zenith. This phenomenon lasted about half an hour. The grandest spectacle of this kind, seen in Great Britain, was observed at Leeds, on the 12th of April, 1783, between nine and ten at night. A broad arch of a bright pale yellow, with an apparent breadth of about 15°, arose in the heavens, and passed considerably south of the zenith; by its varied density, it appeared to consist of small columns of light, with a sensible motion. After about ten minutes, innumerable bright coruscations shot out at right angles from its northern edge, elongating themselves till they had nearly reached the northern horizon. As they descended, their extremities were tipped with an elegant crimson, like that produced by the electric spark in an exhausted tube. After some time this beautiful northern light ceased to shoot, and, forming a range of bright yellow clouds, extended horizontally about the fourth of a circle; its greatest portion, which darted from this arch northwards, as well as the cloud-like and more stationary aurora, became so dense as to hide the stars from view. The moon was eleven days old, and shone brightly during this scene, but did not eclipse the splendour of these coruscations. The wind was in the north, a little to the east. A similar phenomenon was observed at Leeds on the 26th of the same month. From a mass or broad column of light in the west, issued three luminous arches, each of which made a different angle with the horizon. They had not been viewed many minutes when they were rendered invisible by a general blaze of auroræ boreales, which possessed the space just before occupied by these arches.

AURUM, Gold. This most precious of all the metals is usually found in a perfectly pure state, possessing a fine rich yellow colour, and a degree of ductility altogether incredible. By far the most copious supplies occur in alluvial soils, situated along the foot of large ranges of mountains, from which it is apparently washed down by the rivers. It occurs likewise, though in smaller quantities, in veins and beds diffused through granite, gneiss, and other primitive rocks; also in porphyry and sand-stone; and it is generally accompanied with quartz and iron pyrites. Alluvial gold is found in the district of Leadhills in Scotland; and it is reported that, in the time of queen Elizabeth, the metal was there collected to the amount of £100,000. It appears also in Glen Turret, in Perthshire, some parts of Cornwall, and in Ireland, near Arklow, in the county of Wicklow. In all those places, however, it presents itself rather as an object of curiosity than of any real value. The same may be said of the veins which occur in primitive rocks in Salzburg, the Tyrol, Transylvania, and at Edelfors, in Sweden, as well as of the golden sands poured down by the Danube, Rhine, Tagus, and other European rivers. Africa is much more prolific of this valued metal. All the streams which flow from the great mountain-ranges in the centre of that continent appear to impregnate their sands with gold. It is found most copiously in Bambouk, Manding, Wangara, and the countries behind the Gold coast. A large quantity is also collected in the mountains behind Mosambique. The islands of Sumatra, Borneo, and Celebes, in the East Indies, contain large stores of alluvial gold, the working of which has been so much improved by the industry of the Chinese, as to render those regions nearly independent of supply from the west. Nothing on the globe, however, can equal the abundance in which the gold occurs throughout the vast regions of South America. The Mexican gold is chiefly alluvial, but partly found in primitive mountains, and mixed with silver, in the mines of that metal. The situation of the Peruvian gold is nearly similar, but the mines do not pay the expense of working, and the chief riches here, as elsewhere, is obtained by washing. The ample supply of gold which is drawn from Brazil is entirely alluvial, deposited along the foot of that great range of mountains which forms the western frontier of that settlement. Humboldt calculates the entire annual produce of the Spanish colonies at 25,000lbs. troy, and that of the Portuguese at somewhat above 20,000. Gold occurs in three other forms, called by Werner brass yellow, grayish yellow, and electrum, or argentiferous native gold. These occur in different parts of Europe, but in such small quantity as not to deserve much consideration here. The ductility and malleability of gold is so great, that its limits are unknown. The weight of a single grain of fine gold leaf will cover 57 square inches. Calculating the specific gravity of the metal with this admeasurement, we find, that 282,000 of these leaves put together would only be an inch thick. It is nevertheless evident that gold is capable of much greater extension, as the gold-beaters are obliged to alloy the gold with copper, to make it hard enough to pass over the irregularities in the skins, which would otherwise pass round them. It is likewise proved by the silver-gilt wire used for lace-making, which is drawn from an ingot of silver previously gilded. Calculating the length and circumference of the wire thus drawn, it is found that the weight of a grain of gold thus employed, has spread itself over a surface of twelve times greater extent than is done by the gold-beaters in making it into leaves; therefore it follows, if the gold could be made into leaves as thin as the covering upon the silver wire, that it would take 3,384,000 leaves to make an inch in thickness.

AURUM MUSIVUM, used by the japanners, and for varnished works, as snuff-boxes, coaches, &c. has all the beautiful appearance of gold in powder. Amalgamate twelve parts of the purest tin with three parts of mercury; the amalgam is then triturated in a stone mortar with seven parts of flowers of sulphur and three parts of sal ammoniac. The mixture is next put into a matrass, and the whole exposed to a gentle sand-heat, until no more white fumes arise. When, upon this, the heat is somewhat raised, cinnabar sublimes, together with some oxygenated muriate of tin: while at the same time, the remaining tin and sulphur unite, forming the aurum musivum, exhibiting a golden yellow and flaky and scaly matter, of a metallic lustre. The main point in this process is the proper regulation of the fire: when too strong, the operation does not succeed; and instead of aurum musivum, the common sulphuret of tin is obtained.

AUSTRAL, the same as *southern*; thus we say, *Australis Corona*, *Australis Piscis*, for Southern Crown, and Southern Fish. *See* CORONA and PISCIS.

AUTOMATON, a seemingly self-moving machine; or one so constructed, by means of weights, levers, pulleys, springs, &c. as to move for a considerable time, as if it were endued with animal life. And according to this description, clocks, watches, and all machines of that kind, are automata. It is said that Archytas of Tarentum, four hundred years before Christ, made a wooden pigeon that could fly; that Archimedes also made similar automata; that Regiomontanus made a wooden eagle that flew forth from the city, met the emperor, saluted him, and returned; also that he made an iron fly, which flew out of his hand at a feast, and returned again after flying about the room; that Dr. Hooke made the model of a flying chariot, capable of supporting itself in the air. Many curious and surprising automata have been witnessed in the present age: thus, we have seen figures that could write, and perform many other actions in imitation of animals: M. Vaucanson made a figure that played on the flute; the same gentleman also made a duck, which was capable of eating, drinking, and imitating exactly the voice of a natural one; and, what is still more surprising, the food it swallowed was evacuated in a digested state, or considerably altered on the principles of solution; also the wings, viscera, and bones, were formed so as strongly to resemble those of a living duck; and the actions of eating and drinking shewed the strongest resemblance, even to the muddling the water with its bill. M. le Droz, of Neufchatel, has also executed some very curious pieces of mechanism: one was a clock, presented to the king of Spain, which had, among other curiosities, a sheep that imitated the bleating of a natural one, and a dog watching a basket of fruit, that barked and snarled when any one offered to take it away; besides a variety of human figures, exhibiting motions truly surprising. The automaton chess-player is yet more surprising. This wonderful piece of mechanism, the invention of M. de Kemplin, an Hungarian gentleman, has for may years lain dormant. It was brought to England in the year 1817, and exhibited in the great room, Spring Gardens, London, and in other places, to the admiration and satisfaction of thousands. We shall here give a description of its mechanism and operations. The room, where it is exhibited, has an inner apartment, within which appears the figure of a man, as large as life, dressed after the Turkish fashion, sitting behind a chest three and a half feet in length, two feet in breadth, and two feet and a half in height, to which it is attached by a wooden seat. The chest is placed upon four castors; and, together with the figure, may be moved to any part of the room. On the plain surface, formed by the top of the chest, in the centre, is a raised immoveable chess-board, upon which the figure has its eyes fixed; its right arm and hand being extended on the chest, and its left arm holding a Turkish tobacco-pipe. The exhibitor begins by wheeling the chest to the entrance of the apartment within which it stands, and in face of the spectators. He then opens certain doors in the chest, two in front, and two at the back, at the same time pulling out a long shallow drawer at the bottom, which contains the chess-men, a cushion for the arm of the figure to rest upon, and some counters. Two lesser doors, and a green cloth screen, contrived in the body of the figure, and its lower parts, are likewise opened, and the Turkish robe which covers them is raised; so that the construction both of the figure and chest internally is displayed. In this state the automaton is moved round for the examination of the spectators; and to banish all suspicion that any living thing is concealed within any part of it, the exhibitor introduces a lighted candle into the body of the chest and figure, by which the interior of each is, in a great measure, rendered transparent, and the most secret corner is shewn. Here it may be observed, that the same precaution to remove suspicion is used, if requested, at the close as at the commencement of a game of chess with the automaton. The chest is divided, by a partition, into two unequal chambers. That to the right of the figure is the narrowest, and occupies scarcely one-third of the body of the chest. It is filled with little wheels, levers, cylinders, and other machinery used in clock-work. That to the left contains a few wheels, some small barrels with springs, and two quarters of a circle placed horizontally. The body and lower parts of the figure contain tubes, which seem to be conductors to the machinery. After a sufficient time, during which each spectator may satisfy his scruples and his curiosity, the exhibitor re-closes the doors of of the chest and figure, and the drawer at bottom; makes some arrangements in the body of the figure; winds up the works with a key inserted into a small opening on the side of the chest; places a cushion under the left arm of the figure, which now rests upon it; and invites any individual present to play a game of chess. In playing a game, the automaton makes choice of the white pieces, and always has the first move. These are small advantages towards winning the game, which are cheerfully conceded. It plays with the left hand, the right arm and hand being constantly extended on the chest, behind which it is seated. This slight incongruity proceeded from absence of mind in the inventor, who did not perceive his mistake till the machinery of the automaton was too far completed to admit of the mistake being rectified. At the commencement of a game, the automaton moves its head, as if taking a view of the board; the same motion occurs at the close of a game. In making a move, it slowly raises its left arm from the cushion placed under it, and directs it towards the square of the piece to be moved. Its hand and fingers open on touching the piece, which it takes up, and conveys to any proposed square. The arm then returns with a natural motion to the cushion, upon which it usually rests. In taking a piece, the automaton makes the same motions of the arm and hand to lay hold of the piece, which it conveys from the board; and then, returning to its own piece, it takes it up, and places it on the vacant square. These motions are performed with perfect correctness; and the dexterity with which the arm acts, especially in the delicate operation of castling, seems to be the result of spontaneous feeling, bending at the shoulder, elbow, and knuckles, and cautiously avoiding to touch any other piece than that which is to be moved, nor ever making a false move. After a move made by its antagonist, the automaton remains for a few moments inactive, as if meditating its next move; upon which the motions of the left arm and hand follow. On giving check to the king, it moves its head as a signal. When a false move is made by its antagonist, which frequently occurs through curiosity to observe in what manner the automaton will act, (as, for instance, if a knight be made to move like a castle,) the automaton taps impatiently on the chest with its right hand, replaces the knight on its former square, and, not permitting its antagonist to recover his move, proceeds immediately to move one of its own pieces, thus appearing to punish him for his inattention. The little advantage in play which is hereby gained, makes the automaton more a match for its antagonist; and seems to have been contemplated by the inventor as an additional resource towards winning the game. —It is of importance that the person matched against the automaton should be attentive, in moving a piece, to place it precisely in the centre of its square; otherwise, the figure, in attempting to lay hold of the piece, may miss its hold, or even sustain some injury in the delicate mechanism of the fingers. When the person has made a move, no alteration in it can take place; and if a piece be touched, it must be played somewhere. This rule is strictly observed by the automaton. If its antagonist hesitate to move for a considerable time, it taps smartly on the top of the chest with the right hand, which is constantly extended upon it, as if testifying impatience at his delay. During the time that the automaton is in motion, a low sound of clock-work is heard, which ceases soon after its arm returns to the cushion, and then its antagonist may make his move. The works are wound up at intervals, after ten or twelve moves, by the exhibitor, who is usually employed in walking up and down the apartment in which the automaton is shewn; approaching the chest however, from time to time, especially on its right side.

AUTUMN, the third season of the year: this begins at the descending equinox, which, in the northern hemisphere, is when the sun enters the sign Libra, about the twenty-second of August, and ends about the same day in December.

Autumnal *Equinox*, the time when the sun enters the descending point of the ecliptic, where it crosses the equinoctial.

Autumnal *Point*, the point of the ecliptic answering to the autumnal equinox.

Autumnal *Signs*, are the signs Libra, Scorpio, Sagittarius, through which the sun passes during autumn.

AVIARY, a place set apart for rearing and feeding birds, which should be so large as to afford the birds some scope to fly about, and if turfed, there will be no appearance of dirt. Good stout small net, doubled, makes a good fence for an aviary; but wire is much better.

AVOIDANCE, in the Canon Law, is when a benefice becomes void of an incumbent, which happens either in fact, as by the death of the person; or in law, as by cession, deprivation, resignation, &c. In the first of these cases the patron must take notice of the avoidance at his peril; but in avoidance by law, the ordinary is obliged to give notice to the patron in order to prevent what is termed an elapse.

AVOIRDUPOIS, the weight for the larger and coarser commodities; such as groceries, lead, &c. Apothecaries buy by avoirdupois, but sell by troy weight. The proportion of a pound avoirdupois to a pound troy is as 17 to 14.

AVOWEE, one who has a right to present to a benefice. He is so called in contradistinction to those who only have the lands to which the advowson belongs, for a term of years, or by virtue of intrusion or disseisin.

AVOWRY, in Law, is when a person distrained sues out a replevin; for then the distrainer must avow and justify his plea, for distraining which is called his avowry.

AXIOM, a self-evident truth, or a proposition, the truth of which is perceived at first sight. Thus, that a whole is greater than a part; that a thing cannot be, and not be, at the same time; and that from nothing, nothing can arise; are self evident truths, or axioms. Axiom is also an established principle in some art or science. Thus, it is an axiom in geometry, that things which are equal to the same thing, are equal to each other; that if to equal things, equal things be added, the wholes will be equal, &c.

AXIS, in Astronomy, an imaginary right line, supposed to pass through the earth, sun, planets, satellites, &c. and about which they perform their respective diurnal rotations. The earth and planets, in their progress through the annual orbit, move in such a manner that the axis of each always keeps parallel to itself, or points to the same parts of the heavens. The axis of the earth is inclined to the ecliptic in an angle of nearly 66½°, a position which is well adapted for promoting the fertility of the earth, and rendering it habitable. Dr. Keill has pointed out many advantages which result from this inclination of the axis, particularly in ripening the fruits of the earth; and he has proved the truth of much that was advanced by Kepler to the same effect. Among other curious particulars, Keill has shewn, that all who live beyond 45° of latitude, and have greatest need of the sun's heat, have more of it during the whole year than if the equator and ecliptic coincided; whereas they who live between the equator and 45° of latitude, and are rather too much exposed to the sun than too little, have, on account of the present inclination, less of the sun's heat than if the earth were in the position of a right sphere.

Axis of the *Horizon*, *Equator*, &c. is a right line drawn through the centre of the respective circle, perpendicular to its plane.

Axis, in Geometry, the straight line in a plane figure, about which it revolves, to produce or generate a solid. Thus, if a semicircle be moved round its diameter at rest, it will generate a sphere, whose axis is that diameter. And if a right-angled triangle be turned about its perpendicular at rest, it will describe a cone, whose axis is that perpendicular.

Axis is yet more generally used for a right line conceived to be drawn from the vertex of a figure to the middle of the base. So the

Axis of a *Circle* or *Sphere*, is any line drawn through the centre, and terminated at the circumference, on both sides.

Axis of a *Cone*, is the line from the vertex to the centre of the base.

Axis of a *Cylinder*, is the line from the centre of the one end to that of the other.

Transverse Axis, in the *ellipse* and *hyperbola*, is the diameter passing through the two foci, and the two principal vertices of the figure. In the hyperbola it is the shortest diameter, but in the ellipse it is the longest.

Conjugate Axis, or *Second* Axis, in the *ellipse* and *hyperbola*, is the diameter passing through the centre, and perpendicular to the transverse axis. It is the shortest of all the conjugate diameters.

Axis of a *Curve Line*, is still more generally used for that diameter which has its ordinates at right angles to it, when that position is possible.

Axis, in Mechanics, a certain line about which a body may turn. Axes are of various kinds; as,

Axis of a *Balance*, the line upon which it moves or turns.

Axis of *Rotation*, the line about which a body really revolves, when it is put in motion. The impulse given to a homogeneous sphere, in a direction which does not pass through its centre, will cause it to revolve constantly round the diameter, which is perpendicular to a plane passing through its centre, and the line of direction of the impressed force. New forces acting on all its parts, and of which the result passes through its centre, will not change the parallelism of its axis of rotation. Thus it is, that the axis of the earth remains always nearly parallel to itself in its revolution round the sun, without its being necessary to suppose, with Copernicus, an annual motion of the poles of the earth round those of the ecliptic. If the body possess a certain figure, its axis of rotation may change every instant. The determination of these changes, whatever may be the forces acting on the bodies, is one of the most interesting problems of mechanics respecting hard bodies, on account of its connexion with the precession of the equinoxes, and the libration of the moon. The solution of this problem has led to a curious and very useful result; namely, that in all bodies there exist three axes perpendicular to each other, round which the body may turn uniformly when not solicited by external forces. On this account, these axes are properly called principal axes of rotation.

Axis of *Oscillation*, is a line parallel to the horizon, passing through the centre, about which a pendulum vibrates, and perpendicular to the plane in which it oscillates.

Axis in *Peritrochio*, one of the five mechanical powers, consisting of a peritrochium or wheel, and moveable together with it about its axis. The power is applied at the circumference of the wheel, and the weight is raised by a rope that is gathered up on the axis while the machine turns round. The power may be conceived as applied at the extremity of the arm of a lever, equal to the radius of the wheel; and the weight as applied at the extremity of a lever, equal to the radius of the axis; only those arms do not meet at one centre of motion as in the lever, but in place of this centre we have an axis of motion, *viz*. the axis of the whole machine.

Axis, in Optics: Optic axis, or visual axis, is a ray passing through the centre of the eye, or falling perpendicularly on the eye.

Axis of a *Lens*, or *Glass*, is the axis of the solid of which the lens is a segment. Or the axis of a glass, is the line joining the two vertices or middle points of the two opposite surfaces of the glass.

Axis of a *Magnet*, is a line passing through the middle of a magnet lengthwise, in such a manner as that, however the magnet is divided, provided the division is made according to a plane in which such line is found, the magnet will be cut or separated into two loadstones; and the extremes of such lines are called the poles of the magnet.

AZIMUTH, an Arabic term in Astronomy, signifying an arc of the horizon intercepted between the meridian of the place, and the vertical circle passing through the centre of an object, and is equal to an angle of the zenith, formed by the said meridian and vertical circle, which is measured by the forementioned arc. The Azimuth is reckoned eastward in the morning, and westward in the afternoon, and is usually estimated to the north or south, as it is nearer to one or other of those points: thus, if it be found that the vertical circle which passes through the zenith, intersects the horizon exactly between the east and the south, then the star's azimuth is said to be 45° eastward of the south; or it is the complement to the easter or western amplitude.

To find the Azimuth, at the Time of the Equinox, trigonometrically, Say,

As radius is to the tangent of the latitude,
So is the tangent of the altitude of the sun or star
To the cosine of the azimuth from the south.

To find the azimuth of a sun or star at any other time, the reader may consult any elementary treatise on astronomy.

Magnetical Azimuth, an arch of the horizon contained between the azimuth circle of the celestial object and the magnetical meridian; or it is the apparent distance of the object from the north or south point of the compass. This is found by observing the object with an azimuth compass, when it is about 10° or 15° high, either in the forenoon or afternoon.

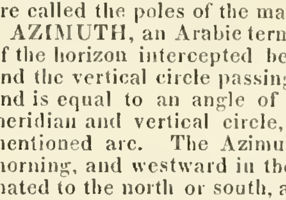


Fig.125.

Azimuth *Compass*, fig. 125, is a compass used at sea for finding the sun's magnetical azimuth; or, more properly, to take the bearing of any celestial object, when it is in or above the horizon, in order to find from the magnetical azimuth, or amplitude, the variation of the needle. The object is viewed through the upright slits or sights, and the bearing is read off on the card, which is divided into degrees, &c.

Azimuth *Circles*, called also vertical circles, are great circles of the sphere, intersecting each other in the zenith and nadir, and cutting the horizon at right angles.

Azimuth *Dial*, is a dial whose stile, or gnomon, is at right angles to the plane of the horizon.

AZURE, in a general sense, the blue colour of the sky; in Painting, a fine blue colour extracted from cobalt and lapis lazuli; but the colour extracted from the latter, is called ultramarine. *See* Colours.

Azure, in Heraldry, the blue colour in the arms of any person below the rank of a baron. In the escutcheon of a nobleman it is called sapphire, and in that of a sovereign prince Jupiter. In Engraving, this colour is expressed by lines drawn horizontally. This colour may signify justice, perseverance, and vigilance; when compounded with

Or,	*it signifies,*	Cheerfulness.
Argent,		Vigilance.
Gules,		Readiness.
Ver,		Enterprise.
Pur,		Goodness.
Sab,		Sorrow.

B.

BAC, in Navigation, a praam or ferry boat; in Brewing, a beer cooler, a large shallow tub; in Distillery, fermenting tubs, are called bacs. And a bac-maker is a cooper, who makes liquor-bacs, underbacs, coolers, mashtubs, working tuns, &c.

BACCHARIS, ploughman's spikenard.

BACK Painting, the method of painting mezzotinto prints, painted on plate or crown glass with oil colours, thus:—the print and glass are to be of one size: the print is soaked in water two hours or longer, till thoroughly moistened; then put between two sheets of clean paper to be dried; the glass is warmed gently, and covered with Strasburgh turpentine: the plate laid on it, and rubbed down closely. Then the whole of the paper is rubbed off with the palm of the hand, but the print, like a thin film, is left upon the glass, and set by to dry. When dry it is varnished with white transparent varnish, and then coloured, or painted with oil-colours, tempered very stiffly; the shadows of the engraving being generally sufficiently deep for the picture.

Back-Staff, an instrument invented by captain Davis for a sea quadrant, and is so named because the back of the observer is turned towards the sun when using the instrument.

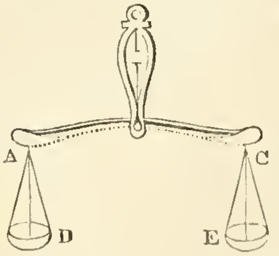
Back-Stays, are long ropes extending from the top-mast heads to both sides of the ship, where they are extended to the channels. Their use is to second the efforts of the shrouds in supporting the mast when strained by a weight of sail. They are usually distinguished into breast back-stays, after back-stays, and shifting back-stays; the first being intended to sustain the mast when the ship sails upon a wind; or, in other terms, when the wind acts upon a ship sideways; the second is to enable her to carry sail when the wind is farther aft; and the third kind take their name from being shifted or changed from one side to the other, as occasion requires. There are also back-stays to the top-gallant-masts.

BACON, Roger, a Franciscan friar, born near Ilchester in Somersetshire, in 1214, and died in 1294. This bright luminary of the thirteenth century, was also a great linguist and grammarian, well versed in the theory of perspective and optics, knew the use of convex and concave glasses, and is said to have been the inventor of gunpowder, at least so far as related to its explosive power: he also understood the erroneous principle of the calendar, and assigned the cause, and proposed the remedy: he possessed great knowledge in the medical art, and was an able mathematician, metaphysician, and theologist. His great learning, however, subjected him to the persecution of his ignorant brethren, who accused him of having dealings with the devil, and he was in consequence confined for ten years, during which time he is said to have prosecuted his studies with the same ardour as before, and with the greatest possible success.

Bacon, Francis, Baron of Verulam, Viscount of St. Alban's, and Lord High Chancellor of England under James I. was born in 1560, and died in 1626; was one of those extraordinary geniuses, who, by giving a new direction to the study of philosophy, have most contributed to the advancement of the sciences. He clearly perceived the imperfection of the philosophy of the old school, and pointed out the only means of reforming it, by proceeding from facts to theories, and by means of experiments to the discovery of the laws of nature. The baron was not, however, immaculate in his office of chancellor; he was impeached for bribery and corruption, found guilty by his peers, and fined £40,000. Alas! that the "*prophet of arts*" should have stooped to receive gifts for the discharge of his duties!

BAIL, is used in our common law to signify the freeing or setting at liberty a person arrested or imprisoned for any action, either civil or criminal, on surety taken for his appearance at a certain place and on a particular day. And the object of bail is to satisfy the condemnation and costs in the action, or render the defendant to prison. In criminal cases, every defendant is not bailable, as for treason, murder, manslaughter, &c.

BALANCE, in Mechanics, a peculiar application of the lever, in order to determine the difference or equality of weights in heavy bodies, and consequently their masses or quantity of matter. There are various kinds of balances; the principal of which, however, are the Common balance, the Bent Lever balance, the Roman balance, and the Swedish or Danish balance. Balances also receive other denominations, according to the circumstances under which they are employed, or the principles on which they act, as Assay balance, Hydrostatic balance, &c.

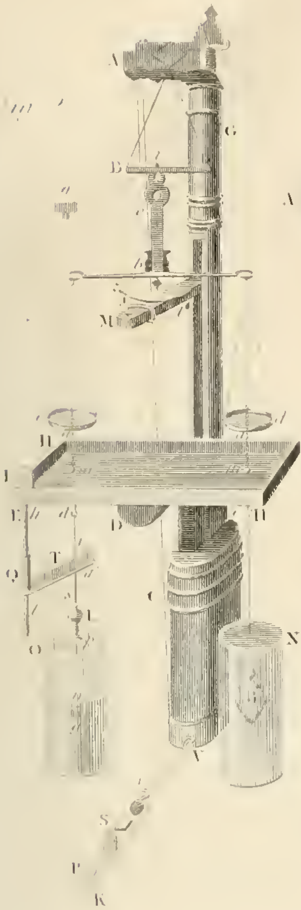


The Common Balance, or *Scale.* This instrument is too well-known to need any particular description; it consists of a lever A C, with equal arms, at the extremity of each of which is attached a scale, as D and E, and, before loading it with any weights, the whole ought to preserve a perfect equilibrium; and this equilibrium must arise from an exact distribution of the weight of each arm and scale of the balance, as well as from the equal length of the former; for on this depends the accuracy of its action. The following observations have been made, with regard to the accuracy of the balance:—"It should rest in a horizontal position when loaded with equal weights. It should have great sensibility; that is, the addition of a small weight in either scale should disturb the equilibrium, and make the beam incline sensibly from the horizontal position. It should have great stability; that is, when disturbed, it should quickly return to a state of rest. That the first requisite may be obtained, the beam must have equal arms, and the centre of suspension must be higher than the centre of gravity. Were these centres to coincide, the beam, when the weights were equal, would rest in any position, and the addition of the smallest weight would overset the

BALANCES.

Hydrostatic Balance

Fig. 2



Roman Balance

Fig. 3

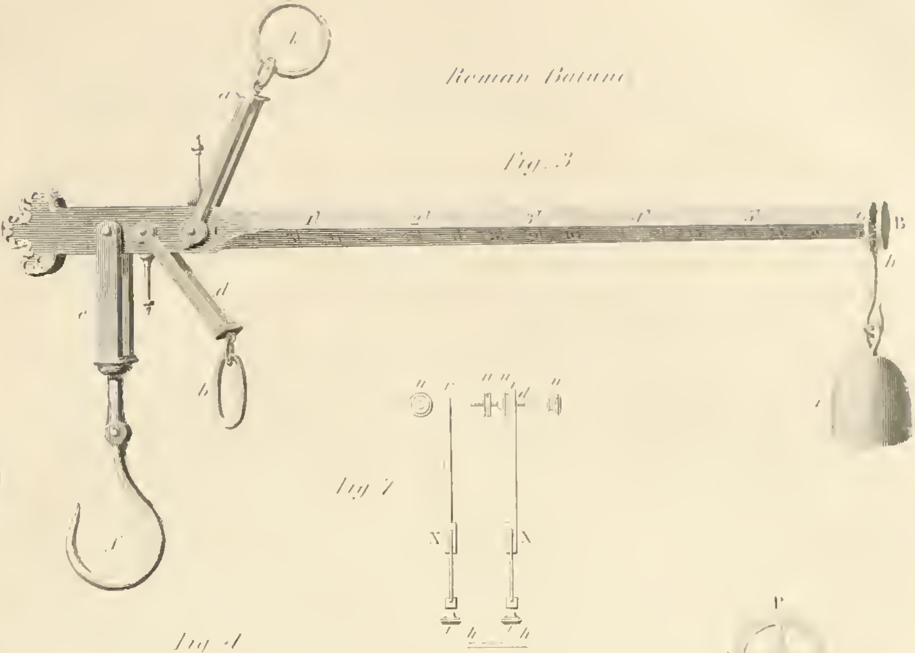


Fig. 7

Fig. 4

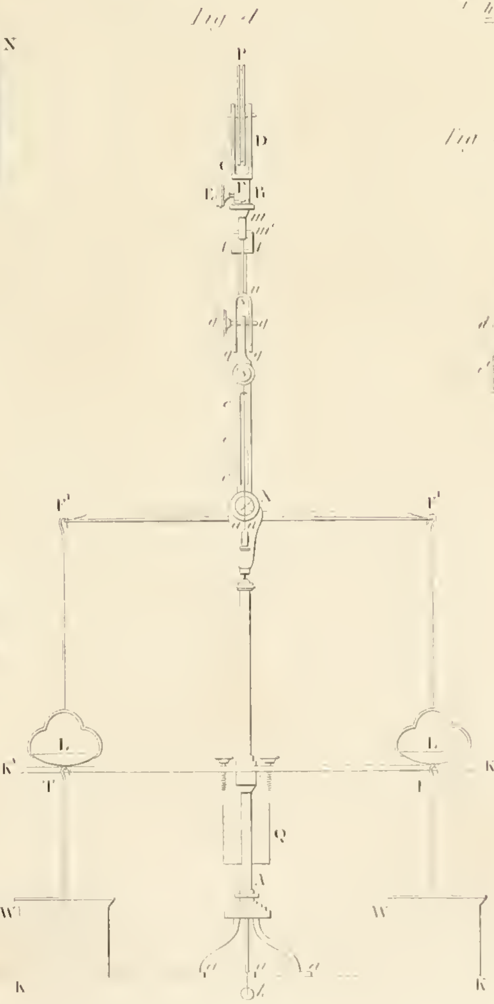


Fig. 6

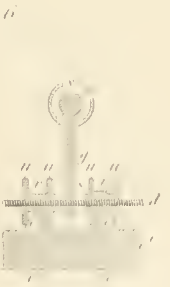
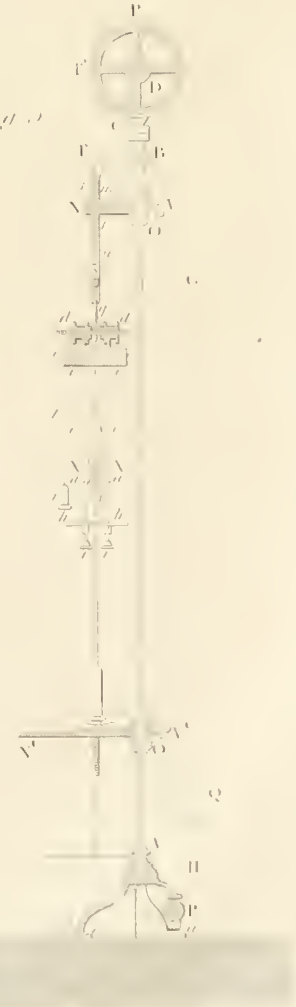
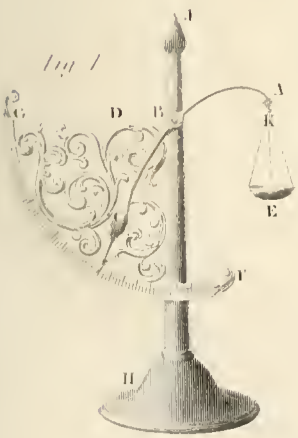


Fig. 5



Bent lever Balance

Fig. 1



Published by . . . . May . 4 . . .

balance, and place the beam in a vertical situation, from which it would have no tendency to return. The sensibility, in this case, would be the greatest possible; but the other two requisites, of level and stability, would be entirely lost. The case would be even worse, if the centre of gravity were lower than the centre of suspension, as the balance, when deranged, would make a revolution of no less than a semicircle. When the centre of suspension is higher than the centre of gravity, if the weights be equal, the beam will be horizontal; and if they be unequal, it will take an oblique position, and will raise the centre of gravity of the whole, making the momentum on the side of the lighter weight equal to that on the side of the heavier, so that an equilibrium will again take place. The second requisite is the sensibility of the balance, or the smallness of the weight by which a given angle of inclination is produced. If a be the length of the arm of the balance, and b the distance between the centre of suspension and the centre of gravity, P the load in either scale, and W the weight of the beam, the sensibility of the balance is as $\frac{a}{b(2\,P + W)}$; it is therefore greater, the greater the length of the arm, the less the distance between the two centres, and the less the weight with which the balance is loaded. Lastly, The stability, or the force with which the state of equilibrium is recovered, is proportional to $(2\,P + W)\,b$, the denominator of the preceding fraction. The diminution of b, therefore, while it increases the sensibility, lessens the stability of the balance. The lengthening of a will, however, increase the former of these quantities, without diminishing the latter. The above formulæ are of great practical utility, because by means of them, one balance may be made, having exactly the same sensibility and stability with another; it is only required that the ratio of the lengths of the arms should be the same with that which is compounded of the ratios of the distances of the centres of gravity and suspension, and of the weights of the beams.—A balance made by Ramsden for the Royal Society, is capable of weighing ten pounds, and turns with half a grain, or a millionth part of the weight. The descriptions of balances, given by mechanical writers, are generally defective, as they do not give the values of a, b, and W, the quantities on which the merit of the balance depends, and by the knowledge of which, similar instruments might be constructed. In some of the nicest balances, b is made variable by means of a small moveable weight."

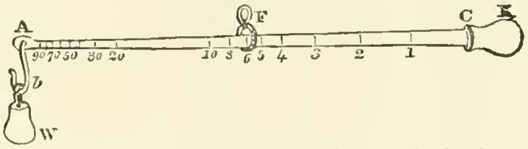
Compound BALANCE, is a combination of several balances employed in weighing very heavy bodies, as anchors, great guns, &c.

Bent Lever BALANCE. See Plate, *Balances*, fig. 1. This instrument operates by a fixed weight C at the end of the bent lever A B C, supported on its axis B, in the pillar I H, having a scale E suspended from the other extremity of the lever at A. Draw the horizontal line K B G through B, the centre of motion, on which from A and C let fall the perpendiculars A K, C D; then if B K and B D are reciprocally in proportion to the weights at A and C, they will be in equilibrio; but if not, the weight C will move upwards or downwards along the arc F G, till that ratio be obtained. If the lever be so bent, that when A coincides with the line GK, C coincides with the vertical B H, then as C moves from F to G, its momentum will increase, while that of the weight in the scale E will decrease; hence the weights in E corresponding to different positions of the balance, may be expressed on the graduated arc F G, and the whole used in the same way as the steelyard.

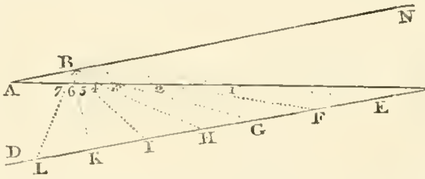
Hydrostatic BALANCE, (*Plate*, fig. 2,) an instrument used for determining the specific gravity of bodies, whether fluid or solid: there are various constructions given to this instrument, but the following appears to be of all others the most accurate. V C G, is the stand or pillar of this hydrostatic balance, which is to be fixed in a table. From the top A hangs, by two silk strings, the horizontal bar B B, from which is suspended, by a ring i, the fine beam of a balance b; which is prevented from descending too low on either side by the gently springing piece $t\,x\,y\,z$, fixed on the support M. The harness is annulated at o, to shew distinctly the perpendicular position of the examen, by the small pointed index fixed above it. The strings by which the balance is suspended, passing over two pulleys, one on each side the piece at A, go down to the bottom on the other side, and are hung over the hook at v; which hook, by means of a screw P, is moveable about one inch and a quarter, backward and forward, and therefore the balance may be raised or depressed so much. But if a greater elevation or depression be required, the sliding piece S, which carries the screw P, is readily moved to any part of the square brass rod V K, and fixed by means of a screw. The motion of the balance being thus adjusted, the rest of the apparatus is as follows:—H H is a small board, fixed upon the piece D, under the scales d and e, and is moveable up and down in a low slit in the pillar above C, and fastened at any part by a screw behind. From the point in the middle of the bottom of each scale, hang, by a fine hook, brass wires $a\,d$ and $a\,c$. These pass through two holes m, m in the table. To the wire $a\,d$ is suspended a curious cylindric wire $r\,s$, perforated at each end for that purpose: this wire $r\,s$ is covered with paper, graduated by equal divisions, and is about five inches long. In the corner of the board at E is fixed a brass tube, on which a round wire $h\,l$ is so adapted as to move neither too tight nor too free, by its flat head I. Upon the lower part of this moves another tube Q, which has sufficient friction to make it remain in any position required: to this is fixed an index T, moving horizontally when the wire $h\,l$ is turned about, and therefore may be easily set to the graduated wire $r\,s$. To the lower end of the wire $r\,s$ hangs a weight L; and to that a wire $p\,n$, with a small brass ball g, about one-fourth of an inch diameter. On the other side, to the wire $a\,c$, hangs a large glass bubble B′ by a horse-hair. Let us first suppose the weight L taken away, and the wire $p\,n$ suspended from S, and, on the other side, let the bubble B′ be taken away, and the weight F, suspended at c, in its room. This weight F we suppose to be sufficient to keep the several parts hanging to the other scale in equilibrium; at the same time that the middle point of the wire $p\,n$ is at the surface of the water in the vessel O. The wire $p\,n$ is to be of such a size, that the length of one inch shall weigh four grains. Now it is evident, since brass is eight times heavier than water, that for every inch the wire sinks in the water, it will become half a grain lighter and half a grain heavier for every inch it rises out of the water: consequently, by sinking two inches below the middle point, or rising two inches above it, the wire will become one grain lighter or heavier. Therefore, if when the middle point is at the surface of the water in equilibrio, the index T be set to the middle point a' of the graduated wire $r\,s$, and the distance on each side $a'\,r$ and $a'\,s$ contains 100 equal parts; then, if in weighing bodies the weight is required to the hundredth part of a grain, it may be easily had by proceeding in the following manner. Let the body to be weighed be placed in the scale d. Put a weight into the scale e; and let this be so determined, that one grain more shall be too much, and one grain less too little. Then the balance being moved gently up or down, by the screw P, till the equilibrium be nicely shewn at o; if the index T be at the middle point a' of the wire $r\,s$, it shews that the weights put into the scale e are just equal to the weight of the body. By this method we find the absolute weight of the body: the relative weight is found by weighing it hydrostatically in water, as follows:—Instead of putting the body in the scale c, as before, let it hang with the weight F, at the hook c, by a horse-hair, as at B, supposing the vessel N of water were away. The equilibrium being then made, the index T standing between a' and r, at the 36th division, shews the weight of the body put in to be 1095, 36 grains. As it thus hangs, let it be immersed in the water of the vessel N, and it will become much lighter: the scale e will descend till the beam of the balance rests on the support z. Then suppose 100 grains put into the scale d restore the equilibrium precisely, so that the index T stand at the 36th division above a'; it is evident that the weight of an equal bulk of water would, in this case, be exactly 100 grains. After a like manner, this balance may be applied to find the specific gravity of liquids, as is easy to conceive from what has been already said. The weight of a cylinder, of the fluid whose base is E F and altitude A G, will disturb the equilibrium. *See* GRAVITY, *Specific*.

Roman BALANCE, or *Steel-Yard*, (*Plate*, fig. 3.) A B represents an instrument of this kind: *a* the trutina, or handle, on which the beam turns; *k* a ring on which the balance may be suspended on a nail or hook; *f* the hook on which the substance to be weighed, is hung; *c* a collar or guard, by which the hook is fastened to the beam; *h* a swivel; *i* the counterpoise. If now the body to be weighed be fastened to the hook *f*, and the whole suspended by the ring *k*, the division on which the counterpoise is placed to maintain an equilibrium in the balance, will shew the weight of the body required; the weight of the counterpoise *i* being known, and the large divisions 1, 2, 3, &c. equal to the distance between the centre of the balance and the screw which fastens the guard C to the shorter arm of the balance. When the body to be weighed is heavier than the divisions on the longer arm will indicate, the balance is turned the lower side upwards, and suspended on the other ring *b*, by which means the divisions become shorter, because the distance between the trutina *d*, and the screw on which the guard *e* moves, is less: the divisions on this side of the figure extending to 17, whereas they only extend to six on the other. The steelyard itself, and its whole apparatus, should be in equilibrio when suspended on the ring *k* or *b*.

The Danish BALANCE, is a kind of steelyard in common use in many parts of Europe, and is of very simple construction, consisting of a batten of hard wood, having a heavy lump K, as in the annexed figure, at one end, and a swivel hook *b* at the other.



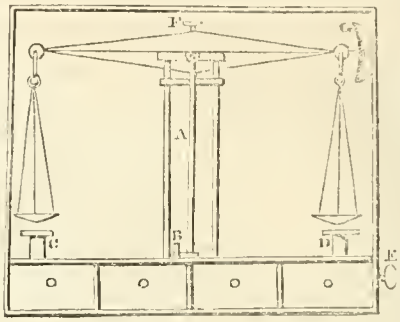
The goods to be weighed are suspended on the hook, and the whole is carried in a loop of whipcord F, in which it is slid backward and forward till the goods are balanced by the weight of the other end. The weight of the goods is estimated by the loop on a scale of divisions, effected by a method purely geometrical:—Let A C (figures 1 and 2,) be the distance between the point A, from which the body whose weight is to be determined is suspended, and C the centre of gravity of the balance when the weight W is not attached to it.



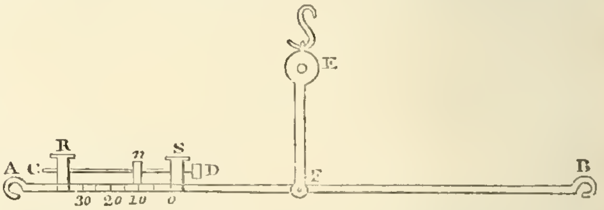
From the point C draw an indefinite line C D, making an angle A C D with the line A C on which the divisions of the balance are to be marked, and through A draw another right line A N parallel to C D. Set off any equal distances C E, E F, F G, G H, H I, &c. along the line C D; and upon A N, set off the distance A B equal to one of the equal distances, as C E, upon C D. From B as a fixed point draw lines B E, B F, B G, B H, &c. to the several points of division on C D; and they will intersect the line A C, in the points 1, 2, 3, 4, 5, &c. where the subdivision marks ought to stand in the balance, figure 1. The numbers 1, 2, 3, 4, &c. fig. 2, denote so many times the actual weight of the balance and its knobs, independent of the adventitious weight W. Thus if the unloaded balance weigh 6 lbs, the distances marked 1, 2, 3, 4, 5, &c. in fig. 2, would correspond to the subdivision marks 6, 12, 18, 24, 30, &c. in fig. 1. The truth of this construction may be easily shewn thus: Let w be the weight of the balance and knob, and W that of the body which is to be ascertained by the instrument. Then, when the point of suspension is that marked 1, fig. 2, we have in the triangles A B 1, 1 C E, the sides A B and C E equal, also angle $BA1 = 1CE$, and $B1A = E1C$; therefore these triangles are both equiangular and equilateral; consequently, $A1 = 1C$, and, by the natures of the lever, and the centre of gravity, $W = w$. Again, in like manner when the point of suspension is 2, the triangles A B 2, 2 C F, are equiangular; and since $FC = 2AB$, we have $C2 = 2A2$, and $W = 2w$. So also the triangles A B 3, 3 C G, are equiangular; whence because $CG = 3AB$, $C3 = 3A3$, and $W = 3w$, and so on, through the whole division.

This balance (says Dr. Gregory,) has been described more on account of its curiosity than actual utility; for in ascertaining large weights it would be extremely cumbersome and difficult to manage. In the determination of weights not exceeding twenty or thirty pounds, it might, however, be rendered very manageable; for it might be about the length of an exciseman's rod, or a walking stick, having a knob of lead at one end; and in this case the divisions near the knob might be so numerous as to enable a person to weigh accurately to quarters of pounds, if not to ounces: the rod might be moved to and fro upon a chair-back, or the edge of a trussel; and thus this instrument might often be more conveniently used than a spring steelyard.

Fidler's BALANCE, as here represented, was made for the Royal Institution, and does not differ much from those constructed by Ramsden and Troughton. The middle column A can be raised at pleasure by the nut B, and supports the round ends of the axis in the forks at its upper extremity, in order to remove the pressure on the sharp edges of the axis within the forks. C and D are pillars which occasionally support the scales, and may be elevated or depressed, by turning the nut E. The screw F raises or depresses a weight within the conical beam, for the purpose of regulating the position of the centre of gravity; and the graduated arc G measures the extent of the vibrations.



An Improvement on this Balance, is represented below, where D C is a micrometer screw, fixed to the arm F A, so that when it is turned round by the nut D, it neither approaches to nor recedes from the centre of motion F. The screw D C works in a female screw, in the small weight n, and by revolving in one direction carries this weight from S to R, and thus gives the preponderance to the scale G. The recession of the weight n from the centre F is measured, as in the common micrometer; and a weight x placed in the scale suspended at A, will be in equilibrio with n, placed at any distance S n, when $x = \frac{Sn \times n}{FA}$.



Prony's BALANCE *Support*, (*Plate*, fig. 4,) for balances of all dimensions, is calculated to render the operations for which these instruments are used more expeditious and convenient, without diminishing their accuracy.

"Several experiments," says he, "in which I was engaged during the course of the last winter, put me under the necessity of contriving a support which might be applied promiscuously to every kind of balance, whether provided with a suspending handle or not, and which, without detriment to its accuracy, should afford me commodious means of successively raising and lowering it. It is well known how embarrassing and laborious the operation of weighing is, when performed with balances supported by the hand; though this is often only the smallest inconvenience with which their use is attended.

"Various artists have contrived supports, commodious in their use, and ingenious in their principle; but as each of these supports can only be adapted to a single balance, they become so expensive as to be out of the reach of the majority of artists and experimentalists. I think, therefore, I shall do them an acceptable service by publishing, in compliance with the request of several eminent chemists, the description of a support, which, besides the advantage of being adapted for all kinds of balances, possesses that of being constructed at a small expense, either in wood or metal.

"A triangular foot of brass A *a*, *a*, *a*, (figs. 4, 5, representing the elevation and section of my apparatus,) has its three extremities *a*, *a*, *a*, firmly screwed down upon a table or horizontal plane. Into the part A of this foot is screwed a cylindrical rod, A B, which may be of any arbitrary length: it may even be convenient to have two of these of different lengths, in order that they may be changed, when we wish to employ the machine for very large balances. Those which I have made use of are, the one half a metre, and the other one metre (39·4 inches) in length.

"A vertical pulley, P, is placed at the top of the stem A B, in such a manner that the same vertical plane passes through the axis of the rod, and through the horizontal axis of the pulley; the block or collar C D of this pulley has at its lower part a tube C B, into which enters, with a gentle friction, the superior extremity of the rod A B; a screw, E, serves to keep the pulley in a fixed position.

"Another pulley, P, fig. 5, is fixed at the bottom of the rod A B, in such a position that the tangent or cord of the pulleys P and P is parallel to the axis of the rod A B.

"A cord K *t p* H G P F, to the end of which is suspended on the outside of the vertical table K a small weight *k*, passes through a hole *t* made in the foot *a*, rolls over the pulleys *p* and P, and is attached at F to a piece *m m' n q*, which has the form of a fork, and to which are suspended (as I shall shortly explain) the balance, the weights, and the substances that are to be weighed. F *m* is a button, which being screwed at the top of the fork, receives the end of the cord, and by means of a knot made on it sustains the fork.

"The tail or handle of this fork is of a prismatic form at the part *m' n*; this prismatic part enters a groove *f f* made at the extremity N of the horizontal piece N O, so that it can slide freely in this groove either upwards or downwards, its course being, however, limited at *m'*, where it is stopped by the enlarged handle of the fork, and at *n* by the greater width produced by the separation of the two branches of the fork.

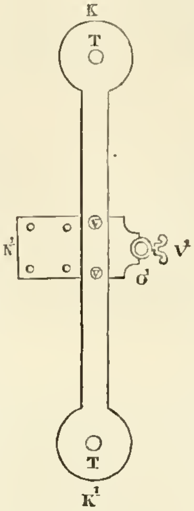
"The piece N O, which is hollow, and intersected at O by the stem A B, can slide along and turn round this stem: when it is brought to its proper height, it is secured by means of the screw V, and it is then necessary, first, that it should be at such a height, that, when the stop *m* rests on the side of the groove *f f*, or when N O can move no further down, the scale of the balance shall be in contact with the table or horizontal plane, in order that we may afterwards be able to raise it the whole height of *f n*; secondly, that the cord F F be in one and the same vertical plane with H G.

"The groove at N ought to be situated in such a manner that the axis of the prismatic part of the tail of the fork, and the cord F F', shall always be in the same vertical plane, or in a parallel line with the axis of the stem A B.

"These dispositions being made, let us imagine the two branches *n q* of the fork to be perforated with holes of different diameters, in order to receive horizontal pins (*g g*) of different sizes; and we shall have all that is requisite for the ordinary operations of weighing, performed in the air with balances, the beams of which are suspended from above.

"In fact, whatever kind of balance we use, we are to introduce the extremity of its suspending handle into the fork *n q*, and insert into the round hole, which the handle of the balance always has at its superior extremity, any one of the pins that will enter with ease; we then apply the piece O N in such a manner as to fulfil the conditions above laid down for the position of this piece; after which, it is to be fixed by the screw V. This being done, the scales of the balance are to be charged, which being in contact with the table, or horizontal plane, can have no motion. When the scales are charged, we lay hold of the small ball *k*, and draw the cord which suspends it so as to raise the balance very slowly: if the scales be not in equilibrio, the cord is to be loosened till they rest again upon the table, and so successively.

"A counterpoise, Q, suspended to the cord F G, ought to preserve the equilibrium with the weight of the balance. By means of this precaution it comes to pass, that the common centre of gravity of all the forces supported by the pulley P, falls in all cases upon the axis of the stem A B, which thus has no tendency to bend.



"If we wish now to use a hydrostatic balance, we adapt to the stem A B a small board O' N' which, by means of a cylindrical hole at O', may slide along the rod A B, and be fixed at any arbitrary height by a screw at V'. Another piece, or board K' K', is placed upon V' N', in such a manner that the holes T T, correspond with the centre of the scales, under which are placed the hooks intended for holding the substances suspended in the water, and K' K' is fixed upon V'N by means of screws V'.

"These arrangements being made, let the piece N' O' and the board K' K', be placed in such a manner that, first, the whole height of the balance be placed between this piece and the board, and that scales L L be in contact with the board K' K', their centres corresponding with holes made in T T. Secondly, that K' K' be sufficiently elevated to enable us to place under it the vessels W W, filled with water, and conveniently to immerse, in one of these vessels, the substances which we wish to weigh hydrostatically.

"According to the common practice, these substances are suspended by a very thin wire; but by placing, after my method, two vessels, and suspending to the two scales wires of equal diameter, the one of which supports the substance that is to be weighed, and the other merely in part immersed, the magnitude of the diameter will have no influence upon the accuracy of the operation; for, let us suppose the apparatus to be adjusted in such a manner that at first the two wires were in equilibrio with each other, (which may easily be obtained by varying the height of the water in the vessels,) these two wires will still be in equilibrio, when the beam F F' being elevated, will remain in its horizontal position: whence it follows, that if one of the wires have suspended from it a substance immersed in the water, and we place in the opposite scale, and consequently out of the water, a weight adequate to keep the equilibrium with the immersed substance, for a horizontal position of the beam, the equilibrium will still be maintained, whatever may be the elevation or depression of the beam, provided it continue in a horizontal position; for the lengths of the wires, either above or below the surface of the water, being equal, the difference between the specific weight of the water and that of the metal will operate equally upon both extremities of the beam. It is evident that this advantage will not be obtained if we employ only the wire to which the substance is suspended, and that the equilibrium, established for a certain elevation and a horizontal position of the beam, will not apply to other elevations of the beam by preserving it in the horizontal position.

"It is to be remarked, that my method compensates not only for the excess of the specific weight of the wires over that of the water, but also for that which depends upon the adhesion of the fluid to the wires, and the covering of water which they carry along with them.

"All that has been said hitherto applies only to balances that are provided with suspended handles; but, in order to render this support absolutely universal in its use, it was necessary that it should be possible to adapt it to a beam which had nothing but its centres; for which purpose I contrived an apparatus, which is suspended, like those of a common balance, to the fork *n q*, and which may receive the centres of any beam. The engravings in the plate represent it provided with this apparatus, the construction of which is as follows.

"A piece ss' fig. 6, has a screwed hole bored into it at s', into which the screw dd is inserted half its length. Another hole, made at s, in a perpendicular direction to the first, receives the pin gg, to which all the inferior apparatus is suspended. This hole s supplies the place of that which is found at the upper extremity of the suspending handle of balances.

"The two other vertical pieces r, r, (fig. 6 and 7,) have at their upper part cylindrical holes not screwed, in which the screw dd can turn freely. These superior parts are placed at an arbitrary distance, and retained in their situation by means of four nut-screws u, u, u, u, each of the pieces being fastened between two of these nut-screws. A cylindrical rod hh traverses the inferior parts of these pieces r, r, and is fixed there by means of nut-screws, in such a manner that the superior and inferior points of the piece rr are invariably at the same distance.

"Each of these pieces r, r has, upon the surface which is perpendicular to the direction of dd and hh, a groove ee, and a circular aperture X, having at its lower part a small bracket of polished steel aa, intended to support one of the centres of the beam. Into the upper part of the grooves ee a rule $e'e'$ is introduced, which must enter with tightness, and which, with the pieces dd and hh, give such a solidity to the apparatus, that the adjustment of its parts cannot be in the smallest degree deranged. The remainder of the groove which is not occupied by $e'e'$, ought to be of a length somewhat greater than that of the largest cock or index adapted to the beams which we shall have to use.

"The method of using the apparatus which I have just described is very simple. The beam which we intend to employ is placed between the two branches r, r, which are removed from each other till the centres can be brought opposite to the circular holes X; the pieces r, r are then brought together in such a manner that the centres enter these holes X, and so as still to leave some room for motion between these pieces and the body of the beam, in order that the oscillations of the balance may be perfectly free. The pieces r, r, are brought parallel with each other, and the adjustment of the apparatus is rendered perfectly firm, by means of nut-screws, by the small cylindrical rod hh, and by the rule $e'e'$. The apparatus being adjusted in this manner, it is suspended to the fork nq, by inserting the pin gg into the hole s, and the balance is used in the manner that has already been explained. We know the equilibrium to be established, and the beam to be horizontal, when the index yy divides the breadth of the space ee into two equal parts; but, in order to ascertain the circumstances with greater accuracy, I have attached to the rule $e'e'$ a plummet $e'i'$, by means of which we may distinguish the slightest deviations of the index from the perpendicular direction."

Balance of a *Clock*, or *Watch*, is that part which by its motion regulates and determines the beats. The circular part of it is called the *rim*, and its spindle the *verge*; there belong to it also two pallets or nuts, that play in the fangs of the crown-wheel: in pocket watches, that strong stud in which the lower pivot of the verge plays, and in the middle of which one pivot of the crown-wheel runs, is called the *potence*: the wrought piece which covers the balance, and in which the upper pivot of the balance plays, is the *cock*; and the small spring in the new pocket watches is called the *regulator*.

The motion of a balance, as well as that of a pendulum, being reciprocating, while the pressure of the wheels is constantly in one direction, it is obvious that some art must be used to accommodate the one to the other. When a tooth of the wheel has given the balance a motion in one direction, it must quit it, that it may get an impulsion in the opposite direction. The balance or pendulum thus escaping from the tooth of the wheel, or the tooth escaping from the balance, has given to the general construction the name of scapement among our artists. *See* Scapement.

Dr. Gregory observes, that some of the most important propositions relative to watch balances may be concisely stated as follows: 1. The balance of a watch is analogous to the pendulum in its properties and use. The simple balance is a circular annulus, equally heavy in all its parts, and concentrical with the pivots of the axis on which it is mounted. This balance is moved by a spiral spring called the balance spring, the invention of Mr. Hook.

2. The pendulum requires a less maintaining power than the balance. Hence the natural isochronism of the pendulum is less disturbed by the relatively small inequalities of the maintaining power.

3. The elastic force of the spring which impels the circumference of the balance is directly as the tension of the spring; that is, the weights necessary to counterpoise a spiral spring's elastic force, when the balance is wound to different distances from the quiescent point, are in the direct ratio of the arcs through which it is wound.

4. The vibrations of a balance, whether through great or small arcs, are performed in the same time. For the accelerating force is directly as the distance from the point of quiescence: hence, therefore, the motion of the balance is analogous to that of a pendulum vibrating in cycloidal arches.

5. The time of the vibration of a balance is the same as if a quantity of matter, whose inertia is equal to that by which the mass contained in the balance opposes the communication of motion to the circumference, described a cycloid whose length is equal to the arc of vibration, described by the circumference, the accelerating force being equal to that of the balance.

6. The times of vibration of different balances are in a ratio compounded of the direct subduplicate ratios of their weights and semidiameters, and the inverse subduplicate ratio of the tensions of the springs, or of the weights which counterpoise them, when wound through a given angle.

7. The times of vibration of different balances are in a ratio compounded of the direct simple ratio of the radii and direct subduplicate ratio of their weights, and the inverse subduplicate ratio of the absolute forces of the springs at a given tension.

8. Hence the absolute force of the balance spring, the diameter and weight of the balance being the same, is inversely as the square of the time of one vibration.

9. The absolute force or strength of the balance spring, the time of one vibration, and the weight of the balance, being the same, is inversely as the square of the diameter.

10. The weight of the balance, the strength of the spring, and time of vibration, being the same, is inversely as the square of the diameter.—Hence, a large balance, vibrating in the same time with the same spring, will be much lighter than a small one.

11. If the rim of the balance be always of the same breadth and thickness, so that the weight shall be as the radius, the strength of the spring must be as the cube of the diameter of the balance, that the time of vibration may continue the same.

12. The momentum of the balance is increased better by increasing its diameter than its weight.

13. The longer a detached balance continues its motion, the better.

14. The greater the number of vibrations performed by a balance in a given time, the less susceptible is it of external agitations.

15. Slow vibrations are, to a certain extent, preferable to quick vibrations: but there is manifestly a limit; for if the vibrations be too slow, the watch will be liable to stop.

16. A balance should describe as large arches as possible, as suppose 240°, 260°, 300°, or an entire circle.—First, because the momentum of the balance is thus increased; and therefore the inequalities in the force of maintaining power bear a less proportion to it, and of consequence will have less influence. 2dly. The balance is less susceptible of external agitations. 3dly. A given variation in the extent of the vibrations produces a less variation in the going of the machine. But care must be taken that in these great vibrations, the spring shall neither touch any obstacle, nor its spires touch each other in contracting.

17. The time of the vibration of the balance is increased by heat, and diminished by cold.—First, because the length of the spiral spring is increased by heat, and therefore its force diminished; and the contrary by cold. 2dly. The diameter of the balance is increased by heat, and therefore also the time of vibration; and the contrary by cold.

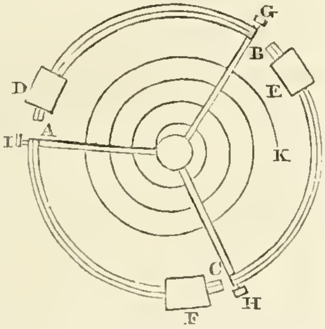
18. That balance is the most perfect, which, without the compensation of a thermometer, is most subject to the influence of heat and cold. Because the obstructions from oil and friction act as a compensation to the expansion or contraction of the

spring and balance; therefore that balance which is most affected is most free from the influence of oil and friction.

19. The errors in the going of a watch, arising from the change of temperature, may be corrected by varying the length of the balance spring. Nevertheless, as it is extremely difficult to form an isochronal spiral, any variation in its length is dangerous, because we shall thus probably lose that point which determines its isochronism.

20. The errors in the going of a watch, occasioned by the variation of temperature, may be corrected by varying the diameter of the balance.

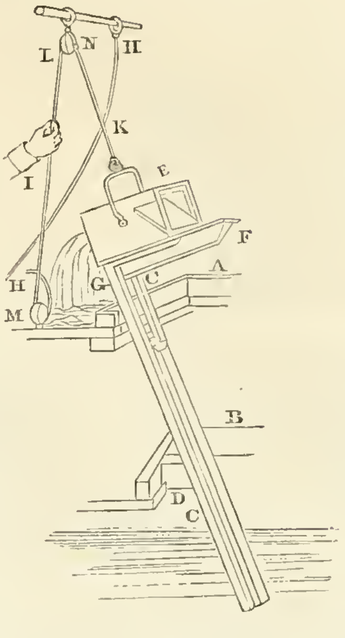
This may be effected by a peculiar contrivance, which has obtained the name of the *expansion balance*, being composed of two different metals which possess different degrees of expansibility, as brass and steel, for instance; of which two metals it has been observed, that the increase of dimensions by expansion, in like elevations of temperature, is nearly as 2 to 1. For, according to Smeaton's experiments, the corresponding expansions of hard steel and brass wire are as 147 and 232, the expansions being occasioned by a change from a medium temperature to that of 180° of Fahrenheit's thermometer. One of the most approved constructions of an expansion balance, is exhibited in the figure annexed, and is thus generally described: The outer part of the rim is brass, and the inner part steel. After this compound rim is brought to its figure by turning, it is cut through in three places A, B, C, which sets one end of each third part of the periphery at liberty to move outwards when the temperature is diminished, or inwards when it is increased. D, E, F, are three similar and equal masses of metal, fitted upon the circular bars in a proper manner to admit of their being fixed at any required distance from the extremity, where the motion is most considerable. G, H, I, are three screws, the heads of which may be set nearer to, or further from, the centre, and serve as weights to effect the adjustments for position and rate. The peculiar advantage of this balance may be explained as follows: when an increase of heat diminishes the elastic force of the pendulum spring K, the outer brass rim being lengthened more than the steel, must throw the weights D, E, F, nearer to the axis, and diminish the effect of the inertia of the balance, which consequently is as speedily carried through its vibration as before. And, on the contrary, when cold weather adds to the elastic force of the spring, the same weights are also thrown further out, and prevent the acceleration which would have followed. The exact adjustment of the weights is found by trial of the going of the machine: if it gain by heat, the weights do more than compensate, and must be moved further from the extreme ends of the circular compound bars; but if the gain be produced by cold, the spring predominates, and the weights will accordingly require to be set further out.



BALCONY, in Architecture, a projection in the front of a house or other building, supported by pillars or consoles, and encompassed with a balustrade or rail.

BALING OF SHIPS. An apparatus for this purpose has lately been invented by J. Dennett of Newport, Isle of White, with a view of assisting sailors in baling vessels when the pumps from accident get out of order. We confess we have too high an opinion of Buchanan's pump, the chain pump, and several other hydraulic engines, to fancy the apparatus before us will ever become very general; but such as the invention is, we give it the reader, with the following decription:

A and B are parts of the hatchways of the upper and lower decks. C C is a long rebated slide, in an inclined position, reaching from a little above the coamings of the upper deck to the ballast in the hold, and attached to the lower hatchway by a block, D. E is a square bucket, made to slide on the rebate of C C; its bottom is a flap valve, so that when it slides down into the water it opens, the bucket fills instantly, and closes upon being drawn up full of water, without any attention on the part of the workmen. The upper portion F of the rebate of the long slide is made detached, and is fixed in its place by the pin G, on which it turns as on an axis. The bucket is shewn discharging the water on the upper deck, and when the rope H I K is let go, the bucket falls down, rights itself, and the upper portion F, of the slide, falling down with it, and joining the lower part, the bucket runs down the whole of the slide into the water, is instantly filled, and drawn up again by pulling the parts I K of the rope, the part K having passed through a block, M, on the deck. A pin is fixed in the top of the rebate, so that when the bucket rises up, and is only in the loose portion F, it is stopped by the pin, and the loose portion F, by farther pulling, rises out of its place, and upsets the bucket. To prevent the bucket from being pulled higher up than is requisite to discharge the water, a knot is worked in the rope which stops the block at L. The block L is made fast to any yardarm, and the upper end of the rope K is secured to the same, or elsewhere, just length enough to let the bucket reach the foot of the slide.



BALL, in the Military art, comprehends all sorts of bullets for fire-arms, as cannon balls, which are made of cast-iron; musket bullets, which are cast from lead. *See* GUNNERY.

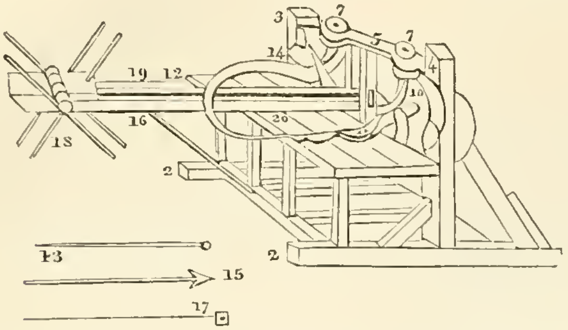
BALL and SOCKET, an instrument made of brass, with a perpetual screw, or so as to move horizontally, vertically, or obliquely, and is generally used for the managing of surveying of astronomical instruments.

BALL, in a popular sense, is any spherical body, whether natural or artificial.

Fire BALLS, in Meteorology, are luminous bodies generally appearing at a great height above the earth, and sometimes amazingly vivid and brilliant. *See* METEOR.

BALLAST, a certain portion of stone, iron, gravel, or such like materials, deposited in a ship's hold, when she has either no cargo, or too little to bring her sufficiently low in the water, and is used to counterbalance the effect of the wind upon the masts, and give the ship a proper stability, that she may be enabled to carry sail without danger of overturning. The art of ballasting consists in placing the centre of gravity so as neither to be too high, nor too low, too far forward, nor too far aft, and that the surface of the water may nearly rise to the extreme breadth a-midships, and thus the ship will be enabled to carry a good sail, incline but little, and ply well to windward. *Shingle Ballast*, is ballast of coarse gravel.

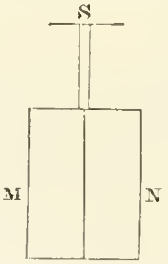
BALLISTA, a machine used by the ancients for shooting darts; which resembles our crossbow. The annexed figure represents one of these engines used in sieges: 2,2 the base of the ballista; 3,4, upright beams; 5,6, transverse beams; 7,7, the two capitals which cannot be seen in this transverse figure; 9,9, two posts or supports for strengthening the transverse beams; 10,10, two skains of cords fastened to the capitals; 11,11, two arms inserted between the two stands, or parts of the skains; 12, a cord fastened to the two arms; 13, darts which are shot by the ballista; 14,14, curves in the upright beams, and in the concavity of the cushions, are fastened in order to break the force of the arms, which strike against them with great force when the dart 15 is discharged; 16, the arbor of the machine, in which a groove or canal perfectly straight is formed, and in which the darts are placed in order to be shot by the ballista; 17 the nut of the trigger; 19, a hook by which the chord is drawn towards the centre, and the ballista cocked; 20, a stage or table, on which the ballista is in part sustained.



Vegetius informs us, that the ballista discharged darts with such rapidity and power, that nothing could resist their force; and Athænæus adds, that Agistratus made one, of little more than a cubit and a half, which shot darts 500 yards.

Balista, was formerly also the name given to the cross-staff.

BALLISTIC Pendulum, an ingenious machine, invented by Robins, for ascertaining the velocity of military projectiles, and consequently the force of fired gunpowder. It consists of a large block of wood M N, suspended vertically by a strong horizontal iron axis at S, to which it is connected by a firm iron stem. Now, to determine the velocity with which a ball is projected, the pendulum is so situated that the ball impinges directly against it, and causes it to vibrate through a certain arc, which being accurately observed, the velocity of projection is thence computed. Dr. Hutton made many experiments of this kind, by discharging cannon-balls at various distances from the pendulum; from which is deduced a complete series of the resistances of the air to balls passing through it, with all degrees of velocities from 0 to 2000 feet per second.



BALLOON, Air. *See* Aerostation.

Le Ballon Aerostatique, the Air Balloon, was placed among the constellations by M. de Lalande, a few years back. It is immediately south of the Zodiacal Goat, west of the Southern Fish, north of Microscopium, and east of Sagittarius.

BALLOTADE, in the Manage, the leap of a horse between two pillars, or upon a straight line, made with justness of time, with the aid of the hand and the calves of the leg, so that when his forefeet are in the air, he shews nothing but the shoes of his hind feet without jerking out.

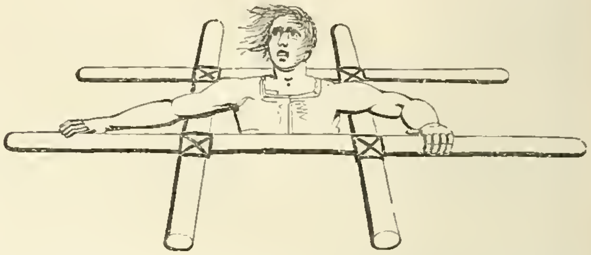
BALLUSTRADE, a series or row of ballusters, joined by a rail, serving as well for a rest to the elbows, as for a fence or enclosure to balconies, staircases, altars, &c.

BALM, a well-known plant, that thrives well in light rich soil, and increases freely by dividing the root. It grows well under the shade of trees, and is a handsome ornament to every flower-garden or cottage. In a fresh state, balm smells something like a lemon, and has a weak rough aromatic taste. On distilling the herb with water, it impregnates the first runnings pretty strongly with its grateful flavour. Prepared as tea, it makes a grateful diluent drink in fevers; and in this way it is commonly used, either by itself, or tempered with lemon juice.

The Balsam of Tolu, from a region on the north coast of South America near the isthmus of Panama, is a resinous fluid, obtained from a tree of the same name by incisions in the trunk, and is useful in medicine both as a tincture and a syrup; it has an agreeable flavour resembling balm, and, made into lozenges, appeases the irritation occasioned by severe coughing.

BAMBOO, a plant, which sometimes grows forty feet high. Its young shoots and roots make an Indian pickle; its light graceful knotted stalk serves, not only in the East for the construction of houses, but for furnishing them with almost every utensil. Tables, chairs, bedsteads, bedding, barrows, fences, sacking, cordage, oakum, candle-wicks, paper, whips, &c. are made from bamboo in China. In Malabar, the bamboos are trained over iron arches, and when they have assumed the curve of the mould, are used for roofs to palanquins, and sell at five or six hundred rupees a set. Might not thousands of cottagers in our own country make money by training the willow, the ash, the hazel, and many other trees and shrubs, into similar arches, for innumerable purposes in common life?

The Chinese Bamboo Habit, to save shipwrecked persons from drowning, consists of four pieces of bamboo, about a man's length, placed horizontally and at right angles, in parallel pairs, and tied firmly at the four corners; the opening being just sufficient to allow the head and shoulders to get through, as represented in the figure, and then tied securely to the body of the person using it. Deal will make this habit equally well.

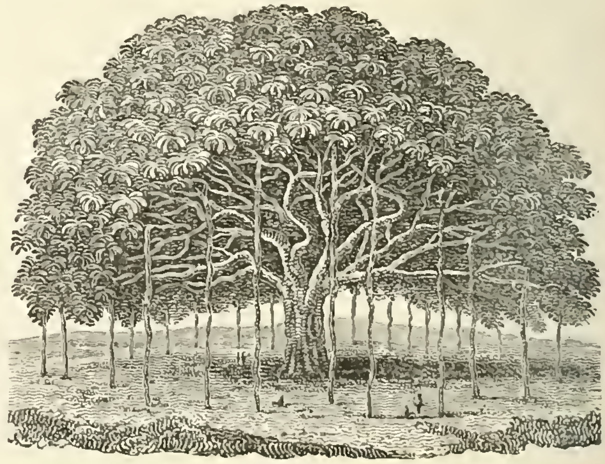


BANANA, a valuable West India plant, whose leaves are six feet long and one foot broad, and the fruit about five inches long, and in shape resembling a cucumber, with a soft luscious pulp, is frequently introduced in desserts, or formed into small loaves, by squeezing out the juice, and leaving it to dry.

BANGLE Ears, an imperfection in a horse, remedied by placing his ears in such a manner as you would have them stand: Bind them with two little boards so fast that they cannot stir, and then clip away all the empty wrinkled skin close by the head.

BANGUE, a species of opiate, in great use throughout the East for drowning care and inspiring joy, is extracted from the leaf of a kind of wild hemp, that grows in the countries of the Levant. The leaves are dried in the shade, ground to powder, and made into pills or conserves, or taken as a powder. The Turks take this deleterious drug and opium as substitutes for wine, which is forbidden by the Koran to all true Mussulmans.

BANIAN Tree, the arched Indian Fig, or God Tree, so named, perhaps, because the Hindoos plant it near their temples, or where no temple exists: the tree itself is made use of for that purpose. The branches of this famous tree descend, take root, and in time are converted into great trunks, so that a whole tree, with all its props, may cover a space of 2000 feet in circumference.



BANN, proscription or banishment for a crime proved; hence, to put a prince under the bann of the empire, is, by sound of trumpet, to declare him divested of all his dignities.—*Episcopal* BANN is a fine paid to the bishop by those guilty of sacrilege, or other crimes.—*The Papal* BANN is excommunication.—In Military affairs, a proclamation by beat of drum or sound of trumpet.

BANQUET, in Fortification, a platform or bank of earth, upon which soldiers stand within the parapet, to fire upon an enemy in the ditch or covert way.

BARBACAN, or BARBICAN, an outer defence or fortification to a city or castle, especially a fence to the city or walls. *See* CASTLE. A fort at the entrance to a bridge, &c.

BARBE, in Military Tactics, means to fire the cannon over the parapet, instead of firing through the embrazures or portholes.

BARBLES, or BARBS, knots of superfluous flesh growing inside the mouths of cattle, and which are cut or burned off, to enable the animals to eat their food.

BARILLA, is the Spanish name of a plant, from the burnt ashes of which is produced a salt called *kali* or *soda*, hard solid masses of a bluish tinge, very heavy, sonorous, dry to the touch, corrosive to the taste, and strongly saline, employed chiefly in the manufacture of glass and soap.

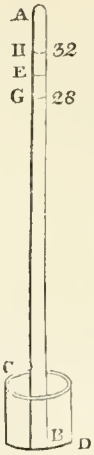
BARK, in Botany, the skin or covering of plants, shrubs, and trees: as oak bark, which is used in tanning; Jesuit's bark, (*cinchona*,) in physic; as also mace, alder, and walnut tree bark, in dyeing; other barks are used in spiceries, as cinnamon, *cassia lignea*. Cork bark is a valuable and useful product. In India and the South Sea islands, cloth is fabricated from the bark of trees.

BARK STOVE, or *Moist Stove*, is a hothouse containing a pit or mass of bark, earth, sand, or other matter, in which the pots containing the plants are plunged, or the plants themselves planted. This house is heated from below, or by the fermentation of the bed of materials, as well as by the atmosphere of the house; and it is used solely for raising and cultivating flowers. The bark-stove floriculture house at Frogmore is truly magnificent. Such houses should be built east and west, though those of the botanic gardens of Dublin and Liverpool are placed with their gables to the south. Loddige's immense palmhouse at Hackney is glazed on all sides.

BARLEY, a well-known grain or corn, used for making malt, meal, bread, or soups; and sugar boiled in barley water is barley sugar, which is rolled on a stone anointed with oil of sweet almonds, and formed into twisted sticks. Whiskey, made of malt, is distilled by a very common chemical process. The malt is dried, mashed, boiled, and from the liquor thus made, the alcohol, or pure spirit, is distilled. Proof spirit consists of half water and half pure spirit; that is, such as when poured on gunpowder, and set on fire, will burn all away, and permit the powder to take fire and flash, as in open air. But if the spirit be not so highly rectified, there will remain some water, which will make the powder wet, and unfit to take fire. Proof spirit of any kind weighs seven pounds twelve ounces per gallon.

BARM, Yeast, first used by the Celtes in making bread. *See* BREAD.

BAROMETER, an instrument to measure the elasticity of air, consists of a hollow glass cone, filled with mercury, and hermetically sealed at the end, so that no air be left in it, as represented in the following figure. When it is set upright, the mercury descends down the tube, into the bubble, which has a little opening at the top, that the air may have free ingress and egress. At the top of the tube there must be a perfect vacuum. The instrument is fixed in a frame, and hung perpendicular against a wall. Near the top, on the frame, is placed a scale of inches, shewing how high the mercury is in the tube, above the level of it in the bubble, which is generally from 28 to 31 inches, but mostly about 29 or 30. Along with the scale of inches, there is also placed a scale of such weather as has been observed to answer the several heights of the quicksilver. In dividing the scale of inches, care must be taken to make proper allowance for the rising or falling of the quicksilver in the bubble, which ought to be about half full when it stands at 29½, which is the mean height; for, whilst the quicksilver rises an inch, it descends a little in the bubble; and that descent must be deducted, which makes the divisions be something less than an inch. These inches must be divided into tenth parts, for the more exact measuring the weight of the atmosphere: for the pillar of mercury in the tube is always equal to the weight of a pillar of the atmosphere of the same thickness; and, as the height of the quicksilver increases or decreases, the weight of the air increases or decreases accordingly. The tube must be near 3 feet long, and the bore not less than ⅕ or ⅙ of an inch in diameter, or else the quicksilver will not move freely in it.



The real cause of the suspension of the mercury in the tube, and of water in pumps, is now generally admitted to be the atmospheric pressure, and repeated observations which have been made, connected with this subject, discover that the column of mercury varies considerably in its height, at different times, and this variation has been observed to be followed by changes of the weather. This, in the infancy of meteorological science, led to farther and more accurate observations, and various alterations and improvements were suggested in the construction of the barometer, or *weather-glass*.

The constructions of this instrument are now exceedingly varied and numerous, much beyond what our limits will admit of enumerating; we must, therefore, content ourselves with describing the most popular and general forms, and refer the reader who wishes for farther information to the article BAROMETER, in Rees's Cyclopedia, where he will find a detailed account of nearly all the forms and uses to which this instrument has been applied.

Common BAROMETER.—This is represented in the figure above, such as it was invented by Torricelli. A B is a glass tube open at one end, and hermetically sealed at the other, A, having its diameter about one-third or one-fourth of an inch, and its length thirty-three or thirty-four inches: this is filled with purified mercury so justly as not to have any air over it, nor any bubbles adhering to the sides of the tube, which is best done by means of a small paper or glass funnel, with a capillary tube. The orifice of the tube, filled after this manner, so as to overflow, is then closely pressed by the finger, so as to exclude any air between it and the mercury; this done, invert the tube, and immerse the finger and end, thus stopped, into a bason of like purified quicksilver, and in this position withdraw the finger, and the mercury will descend in the tube to some place, as E, between twenty-eight and thirty-one inches above the surface of the mercury in the bason at F; these being the limits between which it always stands near the surface of the earth or sea. Instead, however, of the detached vessel C D, the modern barometer tubes are curved at the bottom, and terminate in a bulb, which ought to be as big as it can be conveniently made, in order that the variation in the altitude of the mercury in the tube may affect, as little as possible, the depth of that in the bulb.

The barometer tubes, under either of the above forms, are now to be enclosed in a wooden case or frame, to prevent their being broken, and the vessel or bulb, though open to the air, must be secured from dust; and thus far the construction will be completed.

Next, measure from the surface of the mercury at F, 28 inches to G, and 31 inches to H; dividing the spaces between them into inches and tenths, which are marked on a scale placed against the side of the tube; and these tenths are again subdivided into hundredth parts of an inch, by means of a sliding index carrying a *vernier* or *nonius*. In the common barometers called *weather-glasses*, the lowest limit at G is marked *stormy*, and the highest point, H, is marked on one side *very dry* for summer, and on the other, *very hard frost* for winter. To the next half-inch below the highest point are annexed *set fair* on the one side, and *set frost* on the other. At the height of 30 inches, *fair* is marked on one side, and *frost* on the other. At the height of 29½ inches is marked *changeable*, both for summer and winter; and at 29 inches, *rain* on one side, and *snow* on the other. At 28½ inches, *much rain* on one side, and *much snow* on the other; the lowest division being marked *stormy*, as we have before observed.

The barometer is advantageously employed in measuring the heights of mountains; and for every 103 feet perpendicular that the instrument is carried up a mountain, the mercury falls 1-10th of an inch; 103 feet of air being equal to 1-10th of an inch of mercury on the surface of the earth: that is, to one degree in the scale of the barometer. Thus, on the top of Snowden, in Wales, the mercury sinks 3·67 inches, therefore that mountain is 3720 feet high.

A thermometer should always be attached to the barometer, and by the side of it a scale of correction, to shew how much to add or subtract from the height of the mercury in the barometer, for the degree of temperature; for it is evident, that the mercury in the tube will be affected by heat and cold in the same manner as the thermometer, and, on that account, it will not shew the true weight of the atmosphere. For, by numerous experiments it has been found, that air expands about $\frac{1}{435}$th part of its bulk for every degree of heat, and contracts the same for every degree of cold, and consequently, the result obtained from the above formula must be increased or diminished by as many times $\frac{1}{435}$th part of itself, as the temperature in degrees exceeds, or is less than, 31°. Hence we have another rule for measuring altitudes by the barometer, *viz.*

Observe the height of the mercury at the bottom of the object to be measured, and again at its top; as also the degree of the thermometer in both these situations; and half the sum of these two last may be accounted the mean temperature. Then multiply the difference of the logarithms of the two heights of the barometer by 10,000, and correct the result by adding or subtracting so many times its 435th part, as the degrees of the mean temperature are more or less than 31°; and the last number will be the altitude in fathoms.

Example.—If the heights of the barometer at the bottom and top of a hill are 29·37 and 26·59 inches respectively, and the mean temperature 26°, what is the height?

Log. 29·37 = 1·467904
Log. 26·59 = 1·424718

Difference of Logs. = 0·043186
Multiply by 10000

431·86

Now 31° — 26° = 5° temperature below 31°; therefore $\frac{5}{435}$ of 431·86 = 4·96; consequently 431·86 — 4·96 = 426·90 fathoms, the altitude of the hill.

This requires, however, certain modifications, on account of the difference in low and elevated situations, the expansion of the column of mercury, and other circumstances, which the limits of our article will not admit of investigating. Before M. de Luc began his experiments with the barometer, a mean of the two temperatures shewn by the thermometer attached to the barometer, and the height of the barometer, at the bottom and top of a hill, were thought sufficient for determining its altitude. De Luc, however, found that an additional or detached thermometer was also necessary; and this has been since confirmed by the experiments of General Roy and Sir G. Shuckburgh. The formulæ for the height in fathoms, according to the two latter observers, are as follow:

ROY.

$$\left\{10000\,l = \cdot468\,d\right\} \times \left\{1 + (f - 32^\circ)\cdot00245\right\}$$

SHUCKBURGH.

$$\left\{10000\,l = \cdot440\,d\right\} \times \left\{1 + (f - 32^\circ)\cdot00243\right\}$$

Where l = diff. of logs. of the heights of barometer,
d = diff. of degrees Farhenheit's thermometer,
f = mean of the two temperatures shewn by the detached thermometer exposed for a few minutes to the open air in the shade of the two stations.

The sign — takes place when the attached thermometer is highest at the lower station, and the sign + when it is lowest at that station.

Example.—Find the height of a mountain, from the following observations taken at the foot and summit:

	Barom.	Attach. Therm.	Detach. Therm.
Lowest station,	29·862	68°	71°
Highest station,	26·137	63°	55°

Here we have, d = 5°, difference detached thermometer.
And..........f = 63°, mean of attached thermometer.

Log. 29·862 = 1·475119
Log. 26·137 = 1·417256

Difference of Logs. = 0·057863 = l.

Then, by the first formula,

f — 32° = 31°, and 1 + (31 × ·00245) = 1·07595
10000 l = 10000 × ·057863 = 578·63
·468 d = ·468 × 5 .... = 2·34

576·29
Multiply by 1·07595

620 fathoms,

the altitude sought; the decimals being rejected as unimportant.

Ramsden's engraved table gives the height = 3730 feet, or 621⅔ fathoms. This table is on a slip of paper, a foot long and about 3¼ inches wide; the logarithmic differences, from 25 to 31 inches, are given to 500ths of an inch, and the corrections for the thermometer at both stations found by inspection.

It may be observed, that in determining altitudes by the barometer, it is best to make the observations at the upper and lower stations at one and the same time, as nearly as can be; but great care must be taken that the two barometers, and also the thermometers, are alike; that is, they should precisely agree when together in all states of the air. It is also necessary that the specific gravity of the mercury be well ascertained, because it is not equally pure in all barometers; which is the principal reason why different results have been so frequently obtained, from observations made with different barometers at the same stations. Other circumstances, not generally known, may contribute to such disagreement; thus, Mr. Ramsden proved, by experiment, that the quicksilver in barometer tubes, made of different sorts of glass, will be suspended at different heights.

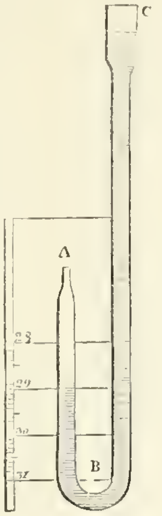
In the following Table, for measuring the altitude of any mountain, the first column expresses its height in feet or miles; the second, the height of the quicksilver; and the third, the descent of the quicksilver in the barometer; and this at a mean density of the air.

Feet.	High. Barom.	Descent.	Feet.	High. Barom.	Descent.
0	29·500				
100	29·400	·100	2600	27·028	2·472
200	29·301	·199	2700	26·933	2·562
300	29·203	·297	2800	26·848	2·652
400	29·105	·395	2900	26·758	2·742
500	29·007	·493	3000	26·668	2·832
600	28·910	·590	3100	26·578	2·922
700	28·812	·688	2200	26·489	3·011
800	28·716	·784	3300	26·400	3·109
900	28·619	·881	3400	26·311	3·189
1000	28·523	·977	3500	26·222	3·278
1100	28·428	1·072	3600	26·136	3·364
1200	28·332	1·168	3700	26·049	3·451
1300	28·237	1·262	3800	25·961	3·539
1400	28·143	1·357	3900	25·874	3·626
1500	28·048	1·452	4000	25·786	3·714
1600	27·954	1·546	4100	25·699	3·801
1700	27·860	1·640	4200	25·613	3·887
1800	27·766	1·734	4300	25·527	3·973
1900	27·672	1·828	4400	25·441	4·059
2000	27·579	1·921	4500	25·355	4·145
2100	27·487	2·013	4600	25·270	4·230
2200	27·394	2·106	4700	25·185	4·315
2300	27·302	2·198	4800	25·101	4·399
2400	27·210	2·290	4900	25·017	4·483
2500	27·119	2·381	5000	24·933	4·567

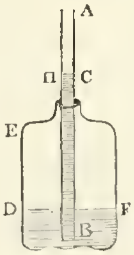
The Table continued, in Miles.

Miles.	High. Barom.	Descent.	Miles.	High. Barom.	Descent.
0·	29·50				
0·25	28·21	1·29	3·25	16·57	12·93
0·50	26·98	2·52	3·50	15·85	13·65
0·75	25·80	3·70	3·75	15·16	14·34
1·	24·70	4·80	4·	14·50	15·00
1·25	23·62	5·88	4·25	13·87	15·63
1 50	22·60	6·90	4·50	13·27	16·23
1·75	21·62	7·88	4·75	12·70	16·80
2·	20·68	8·82	5·	12·15	17·35
2·25	19·78	9·72	5·25	11·62	17·88
2·50	18 93	10·57	5·50	11·12	18·38
2·75	18·11	11·39	5·75	10·64	18·86
3·	17·32	12·18	6·	10·18	19·32

Another sort of barometer shews the ascent and descent of the mercury at the bottom, as A B C (annexed figure) a recurve tube, close at the top, where the bucket C is, and open at the end A. The length of C B is 32 or 33 inches, and of A B 6 or 7. The bucket C should contain about as much as the end A B; and the bucket and end C B must be quite filled with mercury, as far as B, a little beyond the turn. The wider the bucket C is, the better. The scale set to the end A B must be graduated downwards; for the mercury falls in this, when it rises in the other sort. This being placed against a wall, will shew the height of the mercury, as in the common ones; and this way is more commodious, as it saves the labour of clambering up upon chairs to see it, as one must do, in the common sort, to see the index exactly.



A barometer may also be made of water, (as in the lower figure,) which is a water-barometer. A B is a glass tube open at both ends, and cemented close in the mouth of the bottle E F, and reaching very near the bottom; then, warming the bottle at the fire, part of the air will fly out; then the end A is put into a vessel of water mixed with cochineal, which will go through the pipe into the bottle as it grows cold. Then it is set upright; and the water may be made to stand at any point C, by sucking or blowing at A. And, if this barometer be kept to the same degree of heat, by putting it in a vessel of sand, it will be very correct for taking small altitudes; for a little alteration in the weight of the atmosphere will make the water at C rise or fall in the tube very sensibly; but if it be suffered to grow warmer, the water will rise too high in the tube, and spoil the use of it; so that it must be kept to the same temperature.



If a barometer was to be made of water put into an exhausted tube, after the manner of quicksilver, it would require a tube 36 feet long or more; which could hardly find room within doors; but then it would go 14 times more exact than quicksilver; because, for every inch the quicksilver rises, the water would rise 14, from whence every minute change in the atmosphere would be discernible. And the water-barometer, above described, will shew the variation of the air's gravity as minutely as the other, if the bottle be large, to hold a great quantity of air.

The Diagonal BAROMETER acts on the same principle as the common barometer above described, except that the upper end of the tube is bent at about an angle of 45° from the vertical, whereby the scale of variations is increased in about the ratio of 3 to 2; or more accurately, in the ratio of the diagonal of a square to the length of its side. If the upper end be bent in a greater angle, the scale of variation will be so much the more increased; but in practice, it is not found convenient to have the angle much exceeding 45°.

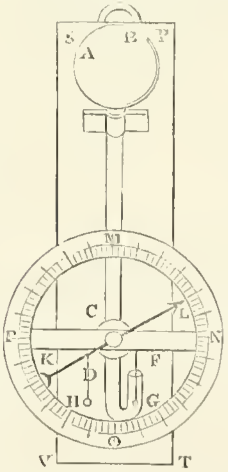
The Horizontal BAROMETER, consists of a tube bent at right angles, having a pretty wide cylindrical part at the upper end of the vertical leg, which is hermetically sealed, the horizontal leg being open, where, however, the mercury cannot run out, being opposed by the pressure of the atmosphere, the variations of which are indicated by a scale attached to that branch of the instrument.

The Marine BAROMETER of Dr. Hooke, is intended to be used on shipboard, being contrived so as not to be affected or injured by the motion of the vessel. It consists of a double thermometer, or two tubes half filled with spirits of wine; the one sealed at both ends, with a quantity of air included; the other sealed at one end only. The former of these is affected only by the temperature of the air; but the other, both by the external temperature, and by the variable pressure of the atmosphere. Hence, considering the spirit thermometer as a standard, the excess of the rise or fall of the other, beyond the former, will shew the increase or decrease of the pressure of the atmosphere. The marine barometer is a very useful instrument for indicating any change in the state of the weather.

The Pendant BAROMETER is rather pretty than useful, and consists of a conical tube placed vertically, its upper and smaller extreme is hermetically sealed, and its larger and lower end open: it has no vessel or cistern, its conical figure supplying that defect; for when filled like the rest, there will be as much mercury sustained as is equivalent to the weight of the atmosphere; and as that varies, the same mercury takes up a different part of the tube, and so becomes of a different weight.

The Portable BAROMETER is so constructed, that it may be carried from one place to another without damage or derangement. The end of the tube is tied up in a leathern bag, not quite full of mercury, which being pressed by the air, forces itself into the tube, and keeps suspended at its proper height. This bag is usually enclosed in a box, through the bottom of which passes a screw, by means of which the mercury may be forced to the upper end of the tube, and prevented from breaking it by dashing against the top, an accident very likely to happen without this precaution.

The Reduced BAROMETER is only three inches long, and serves the purpose of a manometer, in shewing the dilations of the air in the receiver of an air-pump, for which purpose it is now commonly employed.



The Wheel BAROMETER, as here represented, was invented by Dr. Hooke, about the year 1668, and is meant to render the alterations in the air more sensible. Here the barometer tube has a large ball, A B, at top, and is bent up at the lower or open end, where an iron ball, G, floats on the surface of the mercury in the tube, to which is connected another ball, H, by a cord hanging freely over a pulley, turning an index, K L, about its centre. In this instrument the variations of the mercury take place in the lower part of the tube; for the height of the mercury being always the difference between its upper and lower surface, and as in this instrument, in consequence of the great diameter of the ball, the mercury can rise but very little in the upper part, it follows that the most obvious variation must take place in the lower branch. Now, when the quicksilver rises in the part F G, it raises the ball G, and the other ball H descends and turns the pulley, with an index round a graduated circle, from N towards M and P, and the contrary way when the mercury and ball sink in the bent part of the tube. Hence the scale is easily enlarged ten or twelve-fold, being increased in proportion to the axis of the pulley, to the length of the index K L. But then it must be observed, that the friction of the pulley and axis greatly obstructs the free motion of the quicksilver. This imperfection in wheel barometers has been in a great measure obviated by introducing two pulleys, moving on friction wheels.

Various other barometers might here be enumerated, as constructed by Descartes, Huygens, De la Hire, Boyle, Orme, Caswell, Rowning, &c. many of them, however, now out of use, are purposely omitted.

Phenomena of the BAROMETER.—The phenomena of the barometer, considered as a weather-glass, have been very differently stated and explained by various writers; and they are so precarious, that it is extremely difficult to form any fixed and general rules concerning them. Although the barometer never fails to indicate a storm, or any great change of weather, for some hours before it occurs; yet its variations afford no indications that are absolutely certain, with respect to those less considerable changes, to which the weather is subject in our variable climate. With certain restrictions they afford some ground for probable conjecture; and these restrictions are to be determined merely by the sagacity of long-continued observation and experience. Strictly speaking, the height of the mercury in the barometer has no immediate and necessary connexion either with rain or fair weather. That its variable height is the immediate consequence of the variable pressure of the atmosphere, is a fact that admits of no doubt; but the causes of this variable pressure have not yet been fully and satisfactorily ascertained; and how far the state of the weather, in all its minute and sudden changes, depends upon it, is a question that is still to be determined. The mercury is commonly highest in winter and lowest in summer; it is least variable at the solstices, and most variable at the equinoxes. The principal observations that have been made on the variations of this instrument, are summed up in the following particulars:—

1. The more considerable elevations and depressions of the mercury in the barometer happen at a very short interval of time, in places very remote from each other. This correspondence was observed by Mr. Derham, in 1699, between the heights of the mercury at Upminster in Essex, and Townly in Lancashire; and afterwards by M. Maraldi, between the variations at Paris and Genoa, at the distance of nearly four degrees of latitude, who adds, during these variations, different winds prevailed at these places. But Mr. Kirwan observes, that where there is a considerable difference of longitude, the like agreement is not found.

2. The deviations of the mercury from its mean annual altitude are far more frequent and extensive in the neighbourhood of the poles than in that of the equator. At Petersburgh, in 1725, the mercury once stood at the amazing height of 31·59 inches, if we may credit Mr. Consett; and yet it has been so low as 28·14 inches. In the northern parts of France, the variations are greater than in the southern: at Naples, they scarcely exceed one inch. In Peru, under the equator, and at the level of the sea, they amount only to two or three tenths of an inch; but in other parts, within a few degrees of the line, on the approach of the rainy season, or of hurricanes, the barometer falls an inch or more.

3. The variations without the tropics, are greater and more frequent in the winter, than in the summer months.

4. The variations are considerably smaller in very elevated situations than on the level of the sea. Thus M. Bouguer observed, that on the coast of Peru the variations extended to $\frac{1}{4}$ of an inch; at Quito, elevated 9374 feet above the sea, they comprehend only 0·087ths of an inch. Saussure made similar observations in Savoy, as did M. Lambert in Switzerland.

5. The mean height of the barometer on the level of the sea, in most parts of the globe hitherto examined, is about 30 inches: M. Bouguer, under the line, observed it at 29·908 inches; but as his barometer was not purged of air by fire, it stood lower than it should have done. Sir G. Shuckburgh, on a mean of several observations on the coasts of Italy and England, found it at 30·04 inches, when the temperature of the mercury was 55°, and that of the air 62°. The mean height of the barometer in London, upon an average of two observations in every day of the year, kept at the house of the Royal Society, for many years past, is 29·88; the mean temperature or height of the thermometer, according to the same, being 58°. The greatest height observed by Sir G. Shuckburgh, Dec. 26, 1778, in London, was 30·948 inches, the thermometer being at 47°; and, reduced to the heat of 50°, it was 30·957; and this, he says, is the greatest height which, as far as he has been able to collect, it has ever been known to stand at in any country, where observations have been made and recorded, since the first invention of this instrument. In the proximity of the poles, says Mr. Kirwan, the annual mean heights of the barometer differ much more from the standard than in the more southern parts of our hemisphere.

In estimating the connexion of the variation of the barometer with the weather, particular rules have been given by different philosophers; our limits, however, will only allow of stating those of Dr. Halley and Mr. Patrick, which are as follow:—

Dr. Halley's Rules for judging of the Weather.—1. In calm weather, when the air is inclined to rain, the mercury is commonly low.

2. In serene, good, and settled weather, the mercury is generally high.

3. Upon very great winds, though they be not accompanied with rain, the mercury sinks lowest of all, according to the point of the compass the wind blows from.

4. The greatest heights of the mercury are found upon easterly or north-easterly winds, other circumstances alike.

5. In calm frosty weather, the mercury commonly stands high.

6. After very great storms of wind, when the mercury has been very low, it generally rises again very fast.

7. The more northerly places have greater alterations of the barometer than the more southerly, near the equator.

8. Within the tropics, and near them, there is little or no variation of the barometer, in all weathers. For instance, at St. Helena it is little or nothing, at Jamaica $\frac{3}{10}$ths of an inch, and at Naples the variation hardly ever exceeds an inch; whereas in England it amounts to $2\frac{1}{2}$ inches, and at Petersburgh to $3\frac{3}{4}$ nearly.

Dr. Beal, who followed the opinion of M. Pascal, observes, that, *cæteris paribus*, the mercury is higher in cold weather than in warm; and in the morning and evening usually higher that at mid-day: that in settled and fair weather the mercury is higher than either a little before or after, or in the rain; and that it commonly descends lower after rain than it was before it. And he ascribes these effects to the vapours with which the air is charged in the former case, and which are dispersed by the falling rain in the latter. If it chance to rise higher after rain, it is usually followed by a settled serenity. And that there are often great changes in the air, without any perceptible alteration in the barometer.

Mr. Patrick's Rules for judging of the Weather.—These are esteemed the best of any general rules hitherto made:

1. The rising of the mercury presages, in general, fair weather; and its falling, foul weather, as rain, snow, high winds, and storms.

2. In very hot weather, the falling of the mercury indicates thunder.

3. In winter, the rising presages frost; and in frosty weather, if the mercury falls three or four divisions, there will certainly follow a thaw. But in a continued frost, if the mercury rises, it will certainly snow.

4. When foul weather happens soon after the falling of the mercury, expect but little of it; and on the contrary, expect but little fair weather when it proves fair shortly after the mercury has risen.

5. In foul weather, when the mercury rises much and high, and so continues for two or three days before the foul weather is quite over, then expect a continuance of fair weather to follow.

6. In fair weather, when the mercury falls much and low, and thus continues for two or three days before the rain comes, then expect a great deal of wet, and probably high winds.

7. The unsettled motion of the mercury denotes uncertain and changeable weather.

8. You are not so strictly to observe the words engraven on the plates, as the mercury's rising and falling; though in general it will agree with them. For if it stands at much rain, and

then rises up to changeable, it presages fair weather; though not to continue so long as if the mercury had risen higher. And so, on the contrary, if the mercury stood at fair, and falls to changeable, it presages foul weather; though not so much of it as if it had sunk lower.

Upon these rules of Mr. Patrick the following remarks are made by Mr. Rowning: That it is not so much the absolute height of the mercury in the tube that indicates the weather, as its motion up and down: wherefore, to pass a right judgment of what weather is to be expected, we ought to know whether the mercury is actually rising or falling; to which end the following rules are of use:

1. If the surface of the mercury is convex, standing higher in the middle of the tube than at the sides, it is a sign that the mercury is then rising.

2. But if the surface be concave, or hollow in the middle, it is then sinking. And,

3. If it be plain, or rather a very little convex, the mercury is stationary: for mercury being put into a glass tube, especially a small one, naturally has its surface a little convex, because the particles of mercury attract one another more forcibly than they are attracted by glass. Farther,

4. If the glass be small, shake the tube; then if the air be grown heavier, the mercury will rise about half a tenth of an inch higher than it stood before; but if it be grown lighter, it will sink as much. And, it may be added, in the wheel or circular barometer, tap the instrument gently with the finger, and the index will visibly start forwards or backwards, according to the tendency to rise or fall at that time. This proceeds from the mercury's sticking to the sides of the tube, which prevents the free motion of it till it be disengaged by the shock: and therefore, when an observation is to be made with such a tube, it ought to be first shaken; for sometimes the mercury will not vary of its own accord, till the weather is present which it ought to have indicated.

BAROSCOPE, an instrument for shewing the weight of the atmosphere, frequently confounded with barometer: they are not, however, precisely the same; the one being intended only to shew that the air has weight, whereas the other measures that weight, and determines its true quantity.

BARREL, an English vessel or cask, which contains 36 gallons beer measure, and 32 gallons ale measure. The barrel of beer, vinegar, or liquor preparing for vinegar, ought to contain 34 gallons, according to the standard of the ale quart. Barrel is also used as a measure in various commodities; thus,

Barrel of Essex butter is	106 lb.
Barrel of Suffolk butter	256 lb.
Barrel of herrings holds	32 gallons wine measure.
Barrel and contains about	1000 herrings.
Barrel of salmon holds	42 gallons.
Barrel of soap is	256 lb.

Barrel, in Machinery, is also applied to any thing hollow and cylindrical, as the barrel of a pump, of a gun, of a watch, &c.

BARROW, Isaac, a very eminent mathematician and divine of the 17th century, was born at London in October, 1630, and died in May, 1677, in the 47th year of his age. He was the preceptor and friend of the celebrated Newton, by whom only, says Dr. Pemberton, he was surpassed in genius and invention. Barrow was the author of a great number of works both on theology and mathematics.

BARRY, in Heraldry, is when an escutcheon is divided barwise, or from side to side, into any number of compartments, with tinctures interchangeably disposed.

BARTER, is the exchanging of one commodity for another, and forms a rule in the commercial part of arithmetic; is nothing more than simple proportion, or the rule of three, and serves to teach us not to sustain loss in the exchange of goods.

Rule 1.—Find the value of that commodity whose quantity is given; then find what quantity of the other, at the rate proposed, you may have for the same money.—2. When one has goods at a certain price, ready money, but in bartering advances it to something more, find what the other ought to rate his goods at, in proportion to that advance, and then proceed as before.

Example 1. What quantity of chocolate, at 4*s.* per lb. must be delivered in barter for 2 cwt. of tea, at 9*s.* per lb.?

```
  cwt.
    2
  112
  ———
  224
    9
4)2016 the value of the tea.
——————
```

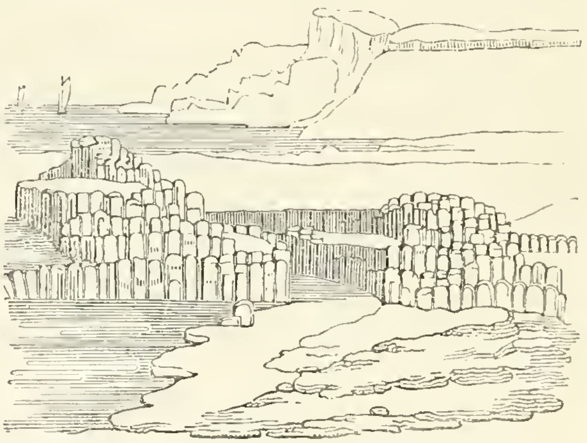
504 lb. of chocolate must be delivered in barter for 2 cwt. of tea at 9*s.* per lb.

Example 2. A and B barter; A hath 20 cwt. of prunes, at 4*d.* per lb. ready money, but in barter will have 5*d.* per lb. and B hath hops worth 32*s.* per cwt. ready money; what ought B to rate his hops at in barter, and what quantity must be given for the 20 cwt. of prunes?

```
           lb.          d.  d.     s.
1 cwt. = 112     As 4 : 5 : : 32
            20                   5
  s.      ————               ————
  40      2240               4)160
  12         5                ————
  —    ———————  c. q. lb.      40s.
  48|0)1120|0(23 1 9 16/48  Answer.
          96
         ————
          160
          144
         ————
           16 = 1 qr. 9 16/48 lb.
         ————
```

BASALTES, in Natural History, a heavy hard stone, chiefly black or greenish, consisting of prismatic crystals, the number of whose sides is uncertain. This mineral always stands upright in columns, and the British dominions present the noblest specimens in the known world of columnar basalt; amongst which, the Giant's Causeway, in Ireland, stands conspicuous. It consists of three piers of basalt columns, which extend some hundred feet into the sea, surrounded by precipitous rocks, from 200 to 400 feet high, in which there are several striking assemblages of columns, some vertical, some bent or inclined, and some horizontal, and as it were driven into the rock. Bengore, which bounds the Causeway on the east, consists of alternate ranges of tabular and massive, with columnar basalt. But among the various and grand objects on this coast, Pleskin is perhaps the most striking: it presents several colonnades of great height and regularity, separated from each other by tabular basalt; and at Fairhead, the north-east cape of Ireland, and forming the east side of Ballycastle Bay, there is a range of columns of from ten to twenty feet diameter, and between 200 and 300 feet high, supported upon a steep declivity, and offering to the mariner at sea the spectacle of a terrace, which towers nearly 600 feet above the waves that roll beneath. Among the Hebrides of Scotland the isles of Ulva, Gometra and Staffa, and Mull, exhibit massive and columnar basaltes, which abounds in black oxide of iron, and bears a strong resemblance to lava, yet the lava of Mount Etna, in the year 1619, ran into the sea for two leagues and a

Giant's Causeway.



half without having the least appearance of being converted into basaltes.

Chemically analyzed Basaltes and Lava give the following results.

Basaltes 100 parts, contain		Lava 100 parts, contain	
Siliceous earth ...... *parts*	50	Siliceous earth ...... *parts*	49
Argillaceous	15	Argillaceous	35
Calcareous	8	Calcareous	4
Magnesia..............	2	Iron	12
Iron	25		100
	100		

The basaltes of Staffa contains 50 parts of flint; the lava of Catanea Mount Etna, 51 parts; the whinstone of Salisbury Craig near Edinburgh, 46 parts of flint; that of the Calton Hill Edinburgh, 50; and the lava of Sta. Veneve, Etna, 50¾ parts flint in every 100 parts. These analogies are very singular in these marbles; which have been considered by some as crystallizations from water.

BASE of a FIGURE, in Geometry, denotes the lowest part of its perimeter; in which sense the base stands opposed to the *vertex*, which denotes the highest part.

BASE of a *right-angled* triangle, is properly the hypothenuse, though it is generally used to denote one of the sides about the right angle, the other side being called the perpendicular; this, however, depends totally upon the position of the figure, as, properly speaking, that side which is lowest, or on which the figure stands, is the base; and for this reason that side on which a solid body stands is called the base of a solid.

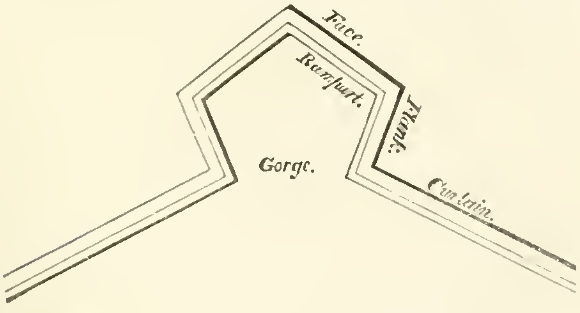
BASE of a *Conic Section*, is a right line in the parabola and hyperbola, formed by the common intersection of the cutting plain and the base of the cone.

BASE, in Surveying, is a line measured with the greatest possible exactness, on which a series of triangles are constructed, in order to determine the position of objects and places.

BASKERVILLE, JOHN, an eminent artist in letter founding and printing, was born at Woverley in Worcestershire, in 1706, and after bringing the printing of books to its greatest perfection, in Birmingham, he died, without issue, in 1776.

BASSOON, a musical instrument of the wind sort, blown with a reed, furnished with eleven holes, and used as a bass in a concert of hautboys, flutes, &c. To render this instrument more portable, it is divided into two parts, whence it is also called a baggot. Its diameter at bottom is nine inches, and its holes are stopped like those of a flute.

BASTION, in Fortification, a large mass of earth, faced usually with sods, sometimes with brick, standing out from a rampart, whereof it is a principal part. The bastion consists of the face, flank, curtain, and gorge, as marked in the figure.

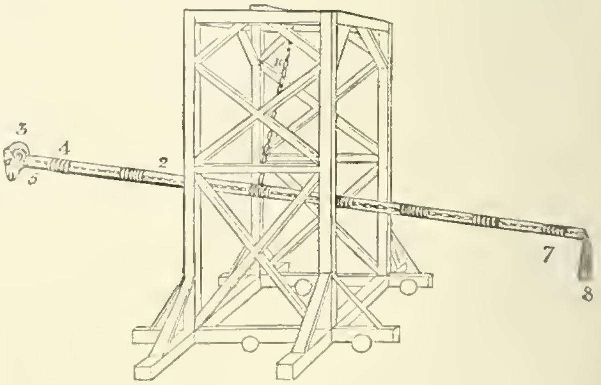


BATH, a receptacle of water in which to plunge, wash, or bathe the body; and the water may be either hot or cold, natural or artificial, of fresh water or of salt. In this country we have hot natural baths at Bath, Bristol, Buxton, and Matlock, which are all beneficial in diseases of the head, palsies, cutaneous diseases, scurvy, obstructions, &c. The Russians cure all diseases by hot baths, and now, in Britain, vapour baths, as Captain Jekyll's, (see the next figure,) are becoming very common. The Captain's bath is also a portable machine, and he carries it about with him, we believe, whenever he removes from his residence in Somersetshire to London.

BATHING, immersing the body in hot or cold water, or in steam, made as it were a part of the existence of the ancients. But when the vapour is passed through a cloud of burning perfumes, the bather is extended freely on a couch, and a servant kneads the whole body without causing the slightest pain, and then rubs the skin with a fine glove, till it becomes soft and smooth like silk; it is then indeed that one experiences a universal comfort, and health resulting from cleanliness: the bath adds both to the happiness and longevity of its votaries.

BATTALION, a small body of infantry, aranged in form of battle, and ready to engage an enemy. It consists of from 500 to 1200 men, armed with firelocks, swords, and bayonets, divided into 13 companies, one of which is the grenadier company. Some regiments consist of one battalion, others of 2, 3, 4, or 6 battalions.

BATTERING RAM, or ARIES, an ancient military engine, employed for destroying the walls of fortified places, of which there were three different sorts; the first rude and plain, the others artificial and compound. The first seems to have been nothing more than a great beam, having a heavy head of iron, which the soldiers bore in their arms, and with one end of it assailed the walls by main strength: this of course was worked at a great expense of labour, and without producing any remarkable effect. The second sort, as described by Josephus, consisted of a very heavy beam, headed with iron as above, and suspended in the middle from another strong beam supported on two posts, which being erected under the walls of the place, was swung backwards and forwards by the soldiers, till, by the repeated shocks thus given, the wall was totally demolished: this machine was sometimes covered by a screen, in order to



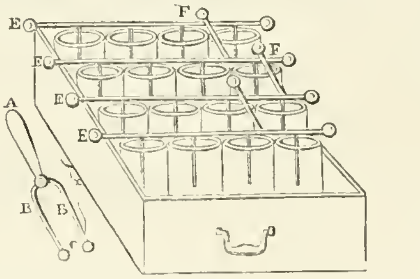
protect the soldiers from the assaults of the enemy. The above figure represents the second kind of battering-ram suspended; 2, the ram; 3, the form of its head, fastened to the enormous beam, by three or four bands of iron, four feet in breadth. At the extremity of each of these bands, (4) was a chain (5) of the same metal, one end of which was fastened to a hook, (6) and at the other extremity of each of these chains was a cable firmly bound to the last link. These cables ran the whole length of the beam, to the end of the ram, (7) where they were all bound together as fast as possible with small ropes. To the end of these cables another was fixed, composed of several strong cords, plaited together, to a certain length, and then running single (8.) At each of these several men were placed to balance and work the machine. 10, the chain or cable by which it hung to the cross beam (11) fixed on the top of the frame: 12, the base of the machine. The unsuspended ram differed from this, only in the manner of working it; for instead of being slung by a chain or cable, it moved on small wheels, on another large beam.

Plutarch informs us, that Marc Antony, in the Parthian war, used a ram of 80 feet long; and Vitruvius says that they were sometimes 106, and even 120 feet long, and weighed 100,000 pounds; at least this is said to have been the weight of that employed by the emperor Vespasian. These battering rams, by their own weight, and by the action of the men who impelled them, excited a force which in some cases exceeded the utmost effect of our battering cannon. Desaguliers (Lectures, vol. i. p. 65) has demonstrated, that the momentum of a battering ram, 28 inches in diameter, 180 feet long, with a head of cast iron of one ton and a half, the whole ram weighing, with its iron hoops, 41,112 pounds, and moved by the united strength of 1000 men, would only be equal to that of a ball of 36 pounds weight shot point blank from a cannon. And Atwood, comparing the effect of the battering ram, having its metal extremity equal to a twenty-four pounder, with a cannon ball of 24 pounds weight, observes, that in order to their producing the same effect in penetrating a wall or making a breach in it, the weight of the ram must exceed that of the cannon ball in the proportion of the square of 1700, the velocity of the ball, to the square of the velocity with which the battering ram could be made to impinge against the wall, expressed in feet. Estimating this at ten feet in a second, the proportion of the weights will be that of about 2,890,000 to 100, or 28,900 to 1; and therefore the weight of the battering ram must be 346 ton. In this case the ram and the cannon ball, moving with the velocities of 10 and 1700 feet in a second, would have the same effect in penetrating any obstacle; but as the weight of the ram was probably never so great as the above supposition states it to have been, the force of a cannon ball to make a breach in walls must exceed that of the ancient aries; but the momentum of this, or the impetus by which it communicated a shock to the whole building, was far greater than the utmost force of cannon balls; for if the weight of the battering ram were no more than 170 times greater than that of a cannon ball, each moving with its respective velocity, the momenta or forces of both would be equal; but as the weight of this ancient machine was certainly much greater than 170 times that of our heaviest cannon balls, their momentum or impetus to shake or overturn walls and demolish buildings, was much superior to that which is exerted by the modern artillery. And since the strength of fortifications will, in general, be proportioned to the means which are used for their demolition, the military walls of the moderns have been constructed with less attention to their solidity and massy weight, than the ancients thought to be a necessary defence against the aries; that sort of cohesive firmness of texture which resists the penetration of bodies, being now more necessary than in ancient times. The ram was frequently used in the fourteenth century. Sir Christopher Wren employed it in demolishing the walls of the old church of St. Paul, previously to his building the present structure; and found no machine so well adapted to this purpose.

BATTERY, in the Military Art, a parapet, thrown up to cover or protect from the enemies' shot, the gunners, and men employed about the guns. In this bank or parapet are cut holes or embrazures, through which the cannon are projected to be fired.

Battery, in Law, is beating another person unlawfully, for which the remedy is, as for assault, by action of trespass *vi et armis*, as the lawyers term it; wherein the jury will give adequate damages.

Battery, in Electricity, is a combination of coated surfaces of glass, commonly jars, so connected together that they may be charged at once, and discharged by a common conductor. Dr. Franklin constructed a battery consisting of eleven panes of large sash glass, coated on each side, and connected in such a manner, that the whole might be charged together, and with the same labour as one single pane; and by bringing all the giving sides into contact with one wire, and all the receiving sides with another, he contrived to unite the force of all the plates, and to discharge them at once. Dr. Priestley describes a still more complete battery: this consists of 64 jars, each 10 inches long, and 2½ inches in diameter, all coated within an inch and a half of the top, forming in the whole about 32 square feet of coated surface. A piece of very fine wire is twisted about the lower end of the wire of each jar, to touch the inside coating in several places; and it is put through a pretty large piece of cork, within the jar, to prevent any part of it from touching the side, by which a spontaneous discharge might be made. Each wire is turned round so as to make a loop at the upper end; and through these loops passes a pretty thick brass rod with knobs, each rod serving for one row of the jars; and these rods are made to communicate together by a thick chain laid over them, or as many of them as may be wanted. The jars stand in a box, the bottom of which is covered with a tin plate; and a bent wire touching the plate passes through the box, and appears on the outside. To this wire is fastened any conductor designed to communicate with the outside of the battery; and the discharge is made by bringing the brass knob to any of the knobs of the battery. When a very great force is required, the size or number of the jars may be increased, or two or more batteries may be used. The large and powerful battery of Dr. Van Marum, constructed for Tayler's museum at Haarlem, consists of a great number of jars coated as above, to the amount of about 130 square feet; and the effects of it are truly astonishing. The annexed figure represents a battery consisting of sixteen jars, coated with tinfoil, and disposed in a proper box. The wires, which proceed from the inside of every four of those jars, are screwed, or fastened, to a common horizontal wire E, which is knobbed at each extremity, and by means of the wires F, F, F, the inside coating of 4, 8, or 12, or of all the sixteen jars, may be connected. The inside of the box which contains these jars is lined with tinfoil. On one side of this box there is a hole, through which a strong wire or hook passes, which communicates with the lining of the box, and of course with the outside coatings of the jar. To this hook a wire is occasionally fastened, which connects it with one branch of the discharging rod, B B C A. By means of the battery, electricity is capable of producing the most powerful effects.



Experiments.—A very slender wire, as *x*, being made part of the circuit, will, by the discharge of the battery, instantly become red-hot. It sometimes melts into small globules of different sizes. If between two slips of window-glass some gold-leaf be placed, and the slips of glass be pressed firmly together, and the shock from a battery be sent through them, the gold-leaf will be forced into the pores of the glass. If the gold-leaf be put between cards, and a strong charge be passed through them, it will be completely fused. Gunpowder may also be fired by the electrical battery.

BATTLE, a general engagement between two armies, in a country sufficiently open for them to encounter, and at the same time, in front. *See* War.

BAYER, JOHN, a German astronomer of the 17th century, who published, in 1603, an excellent work entitled "Uranometria," being a celestial atlas, or charts of all the constellations: he first distinguished the stars by the letters of the Greek alphabet, and according to the order of the magnitude of the stars in each constellation. This work was republished by the author in 1627, under a new title, *viz.* "Cœlum stellatum Christianum:" here he rejected the old figures of the constellations, and inserted others taken from the scriptures: but this innovation was not relished; and accordingly we find, that in the later editions of 1654 and 1661, the ancient figures and names were restored again.

BEAMS, in Naval Architecture, strong thick pieces of timber, stretching across the ship from side to side, to support the decks, and retain the sides at their proper distance, with which they are firmly connected by means of strong knees. They are sustained at each end by thick planks in the ship's side called clamps, upon which they rest.

Midship BEAM, the longest beam in a ship, being lodged in the midship frame, or between the widest frame of timbers. At about two-thirds of the height from the keel to the lower deck, are laid a range of beams to fortify the hold and support a platform called the orlop, which contains the cables and stores of the ship. There are usually twenty-four beams on the lower deck of a ship of seventy-four guns, and to the other decks, additional ones in proportion as the ship lengthens above. It is necessary that the beams should have a greater height in the middle than at the two ends, to carry the water more readily off from the decks, and to diminish the recoil of the guns, which will thereby more easily return to their places.

Orlop BEAMS, support the orlop deck, but are chiefly intended to fortify the hold.

On the BEAM, implies any distance from a ship on a line with the beams, or at right angles with the keel.

Before the BEAM, is an arch of the horizon, comprehended between a line that crosses her length at right angles, and some object at a distance before it; or between the line of the beam and that point of the compass which she stems.

On the Weather BEAM, on the weather side of the ship.

BEAM *ends*, a ship is said to be on her beam ends, when she inclines very much on one side, so that her beams approach to a vertical position; hence also a person lying down is said to be on his beam ends.

BEAM *of a Balance*, the horizontal piece of iron from the ends of which the scales are suspended.

BEAM *Compass. See* COMPASS.

BEAR, *Great and Little*, in Astronomy, the same as Ursa Major and Ursa Minor, which see.

BEARD of a COMET, the rays which it emits in the direction in which it moves, as distinguished from the tail, or the rays emitted or left behind it as it moves along, being always in a direction from the sun. *See* COMET.

BEARING, in Geography and Navigation, the position of one place with regard to another, as estimated by the points of the compass. Thus a place is said to bear north-east, or north-north-east, &c. meaning, that it lies from your present situation in those directions.

BEER-DRAWING MACHINES are contrivances by means of which the beer is drawn from several casks at once, from cocks standing in a frame, in the bar of a tavern, or any convenient place above a cellar. These machines are merely an assemblage of small pumps, either sucking or forcing, whose pipes of communication are attached to the lower parts of the respective casks from which the liquor is drawn. The motion is given to the piston sometimes by levers, at others by cranks; but most frequently by means of a hammer-formed lever moving in a vertical plane.

BEES. There is no kind of stock in which a purchaser is so easily deceived as that of a hive of bees. The following are the best criterions by which to judge of its value. If a hive be purchased in the spring, it should never weigh less than fifteen pounds; if in the autumn, never less than thirty; and if it be a *stock* hive, its weight should be forty pounds, for all old hives contain a certain portion of the *bee bread*. Great care should be taken in weighing a hive, lest the comb should be shaken, and so loosened. The middle of the day is the best time to choose a hive, and the following points should be strictly attended to:

1. The more numerous the bees which enter the hive with yellow balls or pellicles, the better the hive is.

2. The drones should likewise be numerous.

3. The activity of the bees; for if they saunter about, and then re-enter the hive without taking wing, it is a bad symptom.

4. The courage they display in repelling the strange bees.

5. The number of bees who remain at the entrance of the hive fanning with their wings—the greater the internal population: this circumstance is a strong proof of the excellence of a hive.

6. A swarm should always be put into a new hive.

7. The examination of a stock-hive may be pursued with safety, however courageous the bees may appear, by smoking a little tobacco near the hive. But as it may happen that the unskilful apiarian may be stung, the sting should be immediately extracted, and a little goulard water, or laudanum, or sweet oil, instantly applied to it. The mid day is a better time for the examination of a hive than the evening; and the editor of this work performed this very operation on the day he penned these observations.

Internal Appearances of a good Hive.—1. The hive should be crowded with bees.

2. The combs should be *yellow*; if of a blackish tint, reject it.

3. The side combs should be filled with honey; this may be known by their being sealed up.

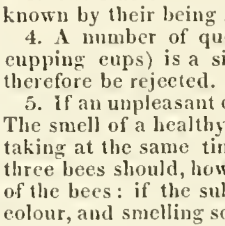
4. A number of queen-bee cells (which resemble inverted cupping cups) is a sign that it is a very old hive; it should therefore be rejected.

5. If an unpleasant odour issue from the hive, it is unhealthy. The smell of a healthy hive resembles that of heated wax, partaking at the same time of the fragrance of honey. Two or three bees should, however, be sacrificed, to ascertain the state of the bees: if the substance in the stomach be of a yellowish colour, and smelling somewhat like honey, the bees are in good health; if, on the contrary, it be blackish, with a fetid smell, the dysentery reigns among them.

6. If dark liquid spots are seen on the board of the hive, it is a bad sign; the dysentery is making ravages within; and if a great number of small particles of wax are also observed, the hive is infested with moths.

7. If the wings of the bees are ragged and torn, the hive is old—have nothing to do with it. The hive should be carefully removed in the evening; the hole of entrance should be stopped up with clay, as well as every other crevice through which a bee could make its escape. Let them settle half an hour before the clay is removed. The hives should stand on separate pedestals a yard apart.

Among the various plans proposed for the cultivation of bees, we shall notice in this place Milton's newly invented double-topped Straw Hive.

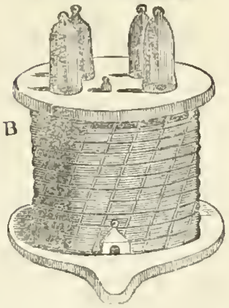


Proceed to hive a swarm in the lower part of the hive in the usual way, as in the figure. The board at the top must be kept close, by securing the openings by means of a thumbscrew, so that when first hived, the holes of both boards shall not correspond, and by thus turning the upper board, it will prevent the bees from passing through while hiving. At night, bring the hive into the bee-house, or where you intend it should stand; in about two days after, place on the glasses, as in the figure, (p. 99,) over their respective openings, and stop them round with mortar; after which, turn the board B to admit the bees to ascend for the purpose of working, cover the glasses with the small upper hive, C, and do not look at them for a few days. Indeed, nothing will then be necessary, but to ascertain when they are filled, which is known by the cell being sealed over, which you may expect in about twenty days after a swarm has been hived.

When you wish to take the honey, and to remove all the glasses, turn the board to exclude the bees; then with a thin knife loosen them from the adapter; leave them thus for about an hour: then carry the glasses, inverted, a short distance from the hive into the shade; or raise the glasses with a small wedge, and those few bees which remain will readily leave, and return to their original hive. This, if effected early in the season, will afford you the opportunity of immediately replacing the same, or another set of glasses, to be again filled.

C

If you wish at any time to take only one or two of the glasses, with honey, do not turn the board, but loosen such glasses as you are desirous to remove, with a thin knife, set them on a divider, and replace others in their stead. The middle of a fine day is the best time to remove glasses. It will not be advisable to take any honey from the hive after the end of July, as the remaining part of the season might not prove favourable to the gathering enough for winter support; therefore it will be necessary, about this time, or early in August, to remove all the glasses and turn the board, to finally shut them up. It may be well to mention, that those glasses, only partly filled with combs, should be carefully set aside, to be placed on again the following April; if, however, you find the stock will require feeding, you have only to leave one or more of the glasses with honey for that purpose, which is by far the best mode.

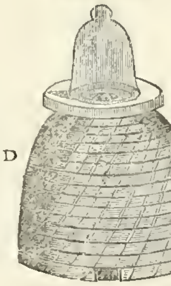

B

Thus much for the swarm, which we now leave till the following April—the time to again commence working the glasses, as hives are now full of combs and brood: should the season prove favourable, you will work the glasses twice or more, and you may calculate upon equal success every subsequent year; but the first season you cannot expect a swarm to fill the glasses more than once, which will produce you 8 lbs of the finest honey.—This method of management will not prevent the bees from swarming.

The honey thus obtained will be of the finest quality, pure, free from the young brood, of remarkably fine fragrance, clear, and very superior to any produced from common hives; it may also be taken at pleasure, without injury to the bees; especially, without being obliged to resort at any time to the painful process of smothering these industrious and valuable insects.

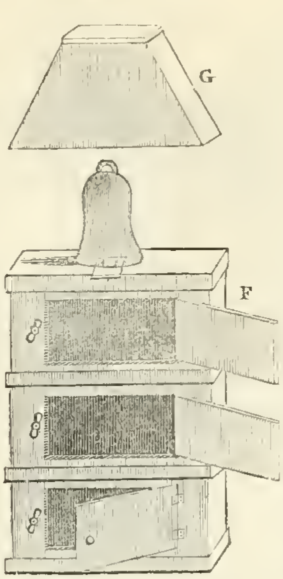
The Double Cottage Straw Hive.—This hive, for use, will answer many purposes in the keeping of bees, as you may work either a glass or a small straw hive on the top of it, which gives it an advantage over the common hive, although the method of management is simple, and the price easy.

E


D

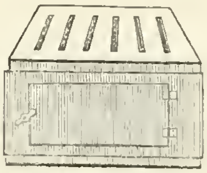
Prepare this hive for a swarm by spreading mortar round the crown, to carry the adapter to support a glass or small straw hive, as you may work with either. Hive the swarm as usual, taking care to secure the opening at the top; after removing it to its appointed place, let the swarm work for ten days; clear the opening at the top, and affix on either a glass or a small straw hive: the bees will then ascend to work. Stop the upper hive round with mortar to the adapter, and darken it with a common hive; in the course of from fifteen to twenty days examine it, and if full, take the honey thus:—pass a knife or wire between the adapter and small hive, to separate the combs; then remove the small hive of honey on a divider, (a tin or brass plate, twelve inches square,) it will then be immediately necessary to place a small hive on the adapter, or stop the opening till you wish to work another hive. Carry the small hive now on the divider a short distance away, or rather into a darkened room; invert it, and place over it a small empty hive of the same size; keep them steady, and, by tapping round the bottom hive, the bees, in a few minutes, will ascend to the hive above; carry them to within about two yards of their original stock, shake them out, and they will enter again as usual.

A Superior Box Hive.—This box hive consists of three divisions, as shewn in the figure, and is so ingeniously constructed, that you may take the finest honey without destroying the bees; you may also work a glass hive on the top, and inspect the whole of their curious and interesting labours without disturbing them.



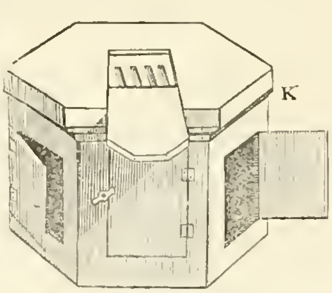
When you place a swarm in this hive, shut the slider of the adapter F, tie a small cord round to secure the parts, hive the swarm in the usual manner; at night bring it into your bee-house, or appointed place, open the entrance at the bottom, and remove the cord; if you work a glass hive on the top, place it on the same evening, stop it round, draw back the slider to clear the grating, leave it a few minutes, and the bees will ascend for working. Then raise the two upper divisions, to enable you to remove the bottom division, and by the compression you oblige the bees to work in the glass hive, which should be darkened with its proper cover G, and left for a few days without being looked at: it will be necessary to replace the unemployed division at the bottom four or five days previous to the removal of the glass of honey; in removing which, shut the slider, and leave it in this state for an hour; then follow those plain directions already laid down for the removal of glass and double-topped straw hives.

If you wish to take more honey from this hive than the glass affords, examine the divisions early in September: if the three are full, *viz.* the two upper hives of honey, and the bottom of combs, *and not otherwise*, proceed to remove the fillets of the top division, and pass the brass divider between those parts, where it should remain for an hour; then raise the division with a wedge, and draw back the slider of the adapter to let the bees out, and when clear, which will be in a few minutes, remove this division, and place the adapter to the next division, and by withdrawing the divider it will fit close down; when you have taken out the combs of honey from this division, it should be replaced at the bottom; consequently, every year, or once in two years, you give them as it were a fresh division, as in the annexed figure, or part of a hive to rebuild in, which keeps the bees constantly at work, and the combs in a good state of preservation.



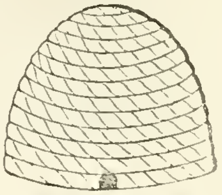
The Hexagon Box Hive and Straw Hive, with slider and grating, for working a large glass hive on the top, consists of a box, as represented in the annexed figure, having large glass windows, and supporting a glass hive on the top. When well supplied with bees, this hive affords the pleasing opportunity of viewing the progress of their labours, and exhibits a very interesting and beautiful appearance.

To hive a swarm, shut the slider over the grating, and then proceed as before directed. When a glass hive is to be worked, follow the instructions already given with the superior box hive. The hexagon hive is well calculated to work bees from other hives, particularly the common hive, especially when they are in a state of decay; it is effected merely by withdrawing the slider clear of the grating, and placing the common hive over it in the evening, taking care to stop the entrance of the former with clay. The bees will of course then enter at the bottom, and when they have worked the bottom hive nearly full, which you ascertain by means of the windows, carefully lift them up, and place under them another hexagon hive; consequently, this colony consists of three hives, and it will not be safe to remove the upper hive, unless the bees have worked combs into the bottom hive, which, if effected at the end of the season, you may safely take the common hive, with its contents.



The flat-topped straw hive, described by Mr. Wildman, is directed to be used in a similar manner, answering the purpose only to a certain extent, as it does not admit of windows, to enable you to know when the bees have finally worked down.

The Common Hive, as here represented, is in such general use in this country, that it requires but little observation, except on some essential points, which, to benefit the cultivator, ought to be attended to. First, care should be taken to have the hive made of clean and good straw, and manufactured of a suitable thickness. Secondly, a hive should be chosen in proportion to the size of the swarm: and when you have succeeded in obtaining a good hive, and placed a swarm in it, which should fill it to within a rim or two of the bottom, shelter it from cold winds and rain; for if once the wet penetrates a hive, it affects the combs, and the bees, getting a distaste for their home, will work very slowly, and often desert it altogether. It is not material in what aspect the stock stands, provided the sun shines on the hive once in the course of the day. Well-peopled hives kept dry, will thrive in any situation.



One of those fatal incidents to which this hive is subject, occurs through covering it with a hackle or turf, by which you entice the mouse to make a nest on the top, and ultimately eat its way through the crown of the hive, and destroy both combs and bees. About August, the robbing commences by stranger bees and wasps, which is but little regarded: an important benefit will be derived by destroying the queen wasp, seen about April, which is the mother of thousands; much, therefore, is saved in the preservation of those hives which stand the winter.

In September, your attention should be directed to weigh your stocks; none of those of less than from fifteen to twenty pounds in weight can safely be relied on to stand the winter, without feeding; and stop all hives down to the board with mortar.

Pasturage, or Bee-Flowers.—Bees are fond of those places where their favourite flowers are to be found; therefore bee-keepers should encourage the growth of such shrubs and flowers as are known to supply honey and wax in the greatest abundance; in most situations bees do not fly far for food, generally not more than half a mile; they may be observed to return with great precipitation to the hive when rain or a storm approaches. The following are the most favourable for pasturage, and those which blossom early are the most desirable:

Shrubs, &c.—All fruit trees, lime trees, furze, broom, heath, sallow or gray willow, rosemary, barberry tree, gooseberry, raspberry.

Flowers.—Hyssop, mustard; turnips, cabbage, and white clover, left for seed; beans in bloom, mignonette, lemon thyme, garden and wild thyme, borage, winter savory.

Mignonette, borage, and lemon thyme, are the principal, as they continue long in bloom, and afford the finest honey. Rosemary is also a great favourite, but seldom supplies much honey, unless the weather proves very hot and dry when it is in blossom, yet it is worth cultivating, especially in a southern aspect, being one of the principal aromatic plants from which the bees in the neighbourhood of Narbonne collect their honey and it is esteemed the finest in Europe. Fields of beans, white clover, and buck-wheat, are of great benefit. Rivers or streams of water are also very beneficial, as bees make use of a great deal of water.

Swarming, or the stock-hive casting part of its inhabitants for a fresh colony, depends on the increase of bees, and a queen being ready to lead them. Their breeding begins sooner or later, according to the forwardness of the spring, the fruitfulness of the queen, and the strength of the hive. When bees carry in farina or pellets on their thighs, it denotes they have commenced breeding, which may be as early as February, and not finish till October; and when their numbers are much increased, they shew the indications of swarming, by their clustering in great quantities below the resting board. They never rise but on a fine day, and sometimes will settle, and for some cause return to the stock, probably for want of a queen being with them. Some hives will cast three times, but mostly only twice. The second cast you may expect within three or four days, and never later than ten days after the first. Should a stock overswarm itself, it will perish, unless strengthened; this may be ascertained by observing the quantity of bees afterwards seen to enter. It is necessary in the swarming season from April to July, particularly in May and June, to observe the hives on a fine day; in general, the bees issue forth in new colonies, about noon—from nine to about three in the afternoon.

Hiving.—Bee-keepers should have spare hives prepared to hive the bees as soon as they have settled; for, should the sun shine hot on the swarm, it may take another flight, and you may possibly lose it. The manner of hiving them must be regulated by the nature of the place on which they settle. The custom of preparing hives varies; a clean new hive only requires the loose straw to be rubbed off with a cloth; if any dressing be used, fennel dipped in boiled ale and sugar will best answer the purpose. Have ready a cloth whereon to place the hive, and a wedge to raise it: if the swarm should settle on a branch, shake the best part of it into the hive, place it on the cloth on the ground, and continue to disturb the swarm where it settled, and the hive being left underneath, they will all go in; or cut the branch off, and gently place it in the hive. Should the bees settle on the ground, place the hive over them; and though bees are not apt to sting at this time, the hiving should be performed quietly. Avoid talking and breathing on them, and if you crush any of them they will resent it; therefore, to prevent accident, invariably put on gloves and a veil, which will give you confidence. All swarms are to be sheltered, and left near to where they settle till the evening; thence to be removed very gently to the appointed place.

Uniting Swarms, and reinforcing Stocks.—It is essential, when you have weak swarms of bees, that you should strengthen them. The idea so prevalent, of the greatest number of hives producing the most honey and wax, is erroneous; for great part of the bees are necessarily employed in rearing the young, and therefore the number of those who are occupied in collecting honey is not so great as has been imagined; for every swarm, the least as well as the greatest, is provided with a queen, equal in fecundity to the queen of the larger stock, and as the brood she brings continually demands the labour and attendance of nearly half the bees, this circumstance renders the other moiety, from the smallness of their number, unable to accumulate a large quantity of honey in the short time it mostly abounds, and therefore honey cannot be obtained, in glass hives or otherwise, but from a strongly-peopled hive.

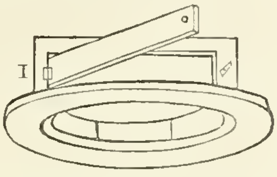
The Method of Uniting:—Hive the swarms or casts in the usual way, and in the evening spread a cloth on the ground, near the hive to be reinforced; bring the new swarm, and strike it down flat on the ground. The bees will then fall in a cluster; quickly place over them the stock to be reinforced; in ten minutes they will have united and become as one family, to be removed the same evening to its former situation.

Another Method of Uniting:—Each cast or swarm to be hived separately; in the evening, turn the crown of the hive into a pail, and set the other hive exactly over it; in the morning, the bees from the bottom hive will have ascended.

The system of uniting, so very important, is but little practised, and has been overlooked by many cultivators; but we are thoroughly convinced, from experience, that it is absolutely necessary to have hives well peopled, and completely sheltered from wet, which are the principal and main objects to be attended to in the art of bee-keeping; and the advantages of uniting swarms will be found particularly beneficial in working the glasses with the newly-invented double-topped hives.

Feeding.—With the aid of feeding, it is perfectly easy to bring any hive of bees through the winter; but to ensure the success of a very light stock, it is essential to keep it also very warm and dry. Feeding is absolutely necessary when you have taken more honey than the hive can afford, by the means of small hives or glasses. Such stocks as are intended to be kept through the winter should weigh twenty pounds or upwards, at the end of September; but casts and late swarms seldom attain this weight, unless two or more should have been united. The composition for feeding consists of moist sugar and new beer, in the proportion of one pound of sugar to a pint of beer, simmered to the consistency of treacle: to be inserted into the hives by means of small troughs, at night, and removed the next morning early. Should a hive be very poor and weak, it is better to feed in larger quantities each time.

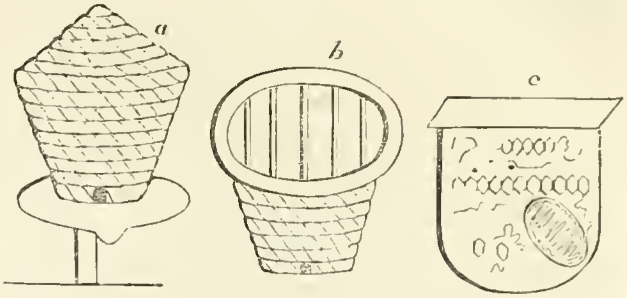
Feeding Machine.—The annexed improved machine for feeding bees, will suit all descriptions of hives:—Prepare a board a little larger than the bottom of the hive, in the centre of which make an opening about ten inches diameter; then form a frame of half-inch deal, to consist of four sides, each about twelve inches by three inches; make the angles firm with small wooden blocks, to which affix the before-mentioned board. A door should then be made in the side of the frame, sufficiently large to admit a deep plate or a small dish, to contain the food. By the use of this machine, the bees are fed quietly, and protected from the cold weather, and the intrusion of other bees. It is scarcely necessary to observe further, that the door of the machine should face such part of the bee-house as best suits your convenience. The dish of food to be placed under should be covered with a piece of thick paper the size of the plate or dish, pierced in holes, through which the bees will feed; and a quantity of short pieces of straw also put into the dish, will prevent the bees from daubing themselves. They should be fed at night, and the dish only taken away early on the following morning; to do this, you should cover your face and hands. The autumn, and early part of the spring, are times proper to examine if any hives require feeding; but always commence before the stock is in absolute want of food, otherwise the bees will be so poor and weak as to be unable to come down.



Honey.—Honey differs much, according to the season of the year when gathered; that obtained in the spring is of much the finest quality; the fragrance and richness of which depends greatly on the pasturage. To judge of the best honey, it should be of a bright pale colour, thick, and a little aromatic. To obtain it from the combs in its pure state, it must be left to run from them without pressing. The properties of honey are much esteemed, and have been noticed by an eminent French physician, Dr. Lemery, in a treatise on foods, in which he says, "Honey heats and strengthens the stomach, is of a lenitive nature—produces nourishment, helps respiration, and is particularly good for those of cold and phlegmatic constitutions."

The newly invented double-topped straw hive, and the other hives described in this article, and every necessary apparatus connected with the apiary, may be obtained at the Repository, 175, Strand; but the following instructions are from Huish's work on bees; and the Huish Hive, which differs entirely from the above, may be had at No. 205, Piccadilly.

Huish's hive is of straw, and resembles a flower-pot inverted, as represented in the annexed figure, with a convex covering of straw also. When the top *a* is removed, several laths are seen, as in *b*, to which the bees attach their combs, and are prevented from getting up into the top by means of a net which covers the laths. *c* represents a lath and comb attached to it, which may be easily removed, according to the following instructions for September.



January.—The bees begin to shew some small degree of activity in this month, when the weather is fine, if they are well. The snow should be carefully brushed off the tops of the hives, and it will be of service to the bees to turn the hives carefully up when the day is warm, and admit a portion of pure air into them. Bad smells and bad air are as prejudicial as bad food to bees. If the bees shew symptoms of dysentery, salt and port wine should be mixed with their food, or diluted brandy.

February.—Bees should be well fed with the following syrup. A pint of ale, a pound of sugar, half an ounce of salt, boiled well, and carefully skimmed: when cold, this mixture will be of the consistence of honey. The stools should be cleaned this month, and sprinkled with salt. The mouth of the hive, which in September was contracted, in order to exclude insects and field mice, should now be enlarged, yet this should only be permitted when the weather is fine; if a fall of snow should again take place, it should be closed,—this should be effected so as to prevent the egress of the bees, but not so as to prevent a circulation of air. A piece of open canvass might be strained over a little frame, and fastened above the hole, which might be raised or lowered at pleasure. In the Huish hives, these slides are of tin. Water should be plentifully supplied in troughs, if no streamlet is at hand, pebbles being placed in it to serve as resting places for the bees.

March.—If, as it frequently happens, the bees of a hive appear languid and weak, and the most generous food appears to be thrown away upon them, the queen of that hive is barren, and the cells are devoid of any fecundated eggs of the last season; they should therefore be joined to the next inferior stock in the apiary. To effect this, the top of the hive to which the bees are to be joined, must be cut off, and the combs laid bare; this is a nice operation, for with the greatest care, much damage will incur; the weak hive must then be well plastered to the lower one, and every crevice filled so as to permit no egress for the bees, except through the entrance of the lower hive. The bees should be fed in the evening, and in the morning the surplus should be removed. The mouth of the hive may now be left at its usual size. Stock hives should be purchased this month. The hives should be kept warm, or sheltered. Young bees may now be seen about the entrance of the hive; the old bees may also be observed cleaning them with their proboscis.

April.—The business of the hive increases daily, and the sight of the first drone should be considered a holiday, as he is the harbinger of a swarm. New hives should be kept in store, to be at hand when wanted. All superfluous and rough straws should be carefully cleared from the interior of the hives, and holes, if any there are, should be stopped with putty or mortar. Singeing or friction will remove the straws—the former is perhaps the best method. The little speckled butterflies now hover about, to steal into the hives, that they may there deposit their eggs. These should be watched, and destroyed.—The queen wasp often appears this month, and should, if possible, be destroyed. If a hive is attacked either by bees or wasps, the only real way to assist its inhabitants is, by removing the hive far away in the evening, and putting an empty one in its place. Some hives will swarm in April, but this is considered rather early.

May.—The bees now becoming very numerous in a healthful hive, many of them fan at the entrance, to refresh their inmates; besides which, small drops of perspiration may be seen on the board, and an increasing blackness also. The clustering of the bees round the mouth of the hive for two or three days together, sometimes at the mouth of the hive, foretels the swarming; and if bees are carefully watched, two or three may be observed, and sometimes more, wandering about, and examining particular objects.

The most usual time of swarming is between the hours of nine A.M. and two P.M. They never swarm while the day is clouded, or in high winds. Yet a sudden gleam of sunshine will oftentimes tempt them to choose their new habitation, even in inclement seasons. All the clatter made by pokers and shovels is absolute nonsense, and would tend rather to scare the bees than settle them; their flight should be watched, and when once they settle, the hive should, if possible, be held under them—a goose wing is of great service in brushing them off; but if they attach themselves to a twig which can be cut off, this should be done. The hive should be well rubbed inside with strong beer, sugar, and salt, as before described; though it is the opinion of some apiarians, that no such preparation is necessary. A good swarm should weigh six pounds: its weight is easily ascertained by weighing the empty hive first. Should a hive appear destitute of drones, some must be caught as they are about to enter other hives, and at evening they must be placed at the entrance of the hive supposed to be destitute of them.

June.—Second swarms take their flight this month; but they give no signs of their departure, and therefore should be well watched. A second swarm is not worth much, but two such swarms together make a good one. The two swarms may be swept into the same hive, and one of the queen bees will be killed by the strongest. But if the proprietor has skill and courage enough to do it, he should kill one of the queen bees himself. Second swarms may be returned to the parent hive in the following manner:—Place the back of a chair parallel with the entrance of the hive, spreading over it a table-cloth, then holding the hive, containing the second swarm, over this, give it a gentle tap or two; the bees will fall on it, and may be gently impelled to their old habitation by a feather or stick. A first swarm commences the construction of the comb in the middle of the hive; the second swarm, at the sides.

July.—The hives should be shaded this month from the intense heat of the sun, to preserve the wax, and consequently the honey. Some persons extract some of the comb at this season of the year. A bee entering the hive with honey, is of a cylindrical form, and of a glossy appearance. The bee without honey, is sun-broiled and wrinkled. When the latter appear numerous, and a correspondent proportion of bees without the pellets of wax are also seen, the hive to which they belong is in a decaying state. Those hives in which the drones are first destroyed, are of particular value.

August.—In those counties where they suffocate the bees, the operation is carried into effect in this month, upon the supposition, that the little creatures begin to live upon their stock; but this is erroneous: if the season is mild, they find food till October. The common spider commits great devastation this month, and care should be taken to destroy him. The entrance of the hive should also be closed, so as to prevent more than two bees entering at the same time, in order to exclude other robbing bees and wasps. The usual way, however, is, to offer a reward for every wasp not destroyed. The humble-bee may also be considered an enemy, since it consumes four times the quantity of the mellifluous juice of flowers than the hive bee. The hives should not be molested during this month, more than can be helped, or than is necessary for their preservation against the attacks of their enemies.

September.—This is the month in which many apiarians take a part of the honeyed store, and the following is the most approved method for effecting this difficult task:—In the first place, no hive should be incommoded by sticks. Presuming that this is not the case, the hive should be carefully turned up; some tobacco being at hand ready for fumigation, the bees will then lose all their courage, and retreat into the corners of the hive; and if they recover from their stupor, a second application of the tobacco will quiet them. The comb should then be carefully cut out, but sparingly. The middle combs should not be touched. When two weak hives are to be joined, Mr. Huish recommends that both should be stupefied by fumigation, and one of the queen bees carefully discovered and killed, the hive to which she belonged being carefully swept into the other. It is the opinion of some apiarians, that the bees should be assisted in the destruction of the drones. The hive should be carefully examined, the stool cleaned, and strewed with salt. Contract the entrance, and plaster the hive to the stool, to keep out all foreign enemies.

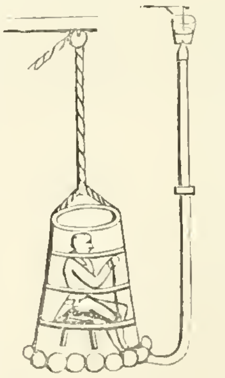
October.—Bees should be well fed this month, with the syrup mentioned in February. The tops of the hives should be examined, and protected from all damp and inclemency of the weather. Cleanliness is absolutely necessary to the prosperity of bees. The entrance should be again contracted, so as to admit only one bee.

November.—The hives should be carefully attended to, and care should also be taken that they have plenty of food. This may be ascertained by occasionally weighing the hive upon the board on which it stands, and marking the decrease of weight. Great cold will affect the bees, and reduce them to a state of torpor, which will end in death, unless relieved by a removal to a warmer situation. Every scattered benumbed bee should be attended to, collected, and when restored to animation by gentle warmth, should be placed at the mouth of the hive, when it will gladly enter. They should be collected in a handkerchief; not in any glazed substance. The field mouse should be watched, and all other vermin and insects; and the hives, if in an exposed situation, should be fastened by a rope to the stand, lest the wind, which frequently happens, should blow them down.

December.—All that the apiarian has to attend to this month, is to keep his hives clear from snow, and confining the bees to their dwelling; and the less they are disturbed in cold weather, the better, since they are kept alive in winter by a reciprocity of animal heat, which is of course diminished if they are compelled to separate, or are shaken.

BELL METAL, of which bells are made, is composed of three parts of copper and one of tin. *See* FOUNDRY.

The Diving BELL.—To illustrate the principle of this machine, take a glass tumbler, plunge it into water with the mouth downwards; you will find that very little water will rise into the tumbler; which will be evident, if you lay a piece of cork upon the surface of the water, and put the tumbler over it; for you will see, that though the cork should be carried far below the surface of the water, yet that its upper side is not wetted, the air which was in the tumbler having prevented the entrance of the water but as air is compressible, it could not entirely exclude the water, which, by its pressure, condensed the air a little.



The first diving-bell of any note was made by Dr. Halley. It is most commonly made in the form of a truncated cone, the smallest end being closed, and the larger one open. It is weighted with lead, and so suspended that it may sink full of air, with its open base downwards, and as near as may be parallel to the horizon, so as to close with the surface of the water. Mr. Smeaton's diving-bell was a square chest of cast iron, four feet and a half in height, four feet and a half in length, and three feet wide, and afforded room for two men to work in it. It was supplied with fresh air by a forcing pump. This was used with great success at Ramsgate. Other contrivances have been used for diving-bells.

The first diving-bell we read of in Europe was tried at Cadiz, by two Greeks, in the presence of Charles V. and 10,000 spectators. It resembled a large kettle inverted. The first person who brought the diving-bell into vogue with us was Phipps, the American blacksmith, in the reign of Charles II., and who, from the fortune he acquired from a Spanish ship, to which he went down, laid the honours of the Mulgrave family. The following is the most useful purpose to which the diving-bell has been applied.

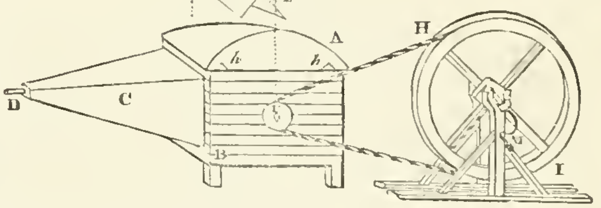
Diving-Bell at Port Patrick.—The diving-bell, or rather the improved instrument now in use at Port Patrick, is neither more nor less than a square cast-metal frame, about 8 feet high, 22 feet in circumference, and weighing upwards of four tons. This frame is, of course, open below, and at the top are twelve small circular windows made of very thick glass, such as are sometimes seen used on board of ships. These windows are so cemented or puttied in, that not a bubble of water can penetrate; and when the sea is clear, and particularly when the sun is shining, the workmen are enabled to carry on their submarine operations without the aid of candles, which would consume nearly as much air as an equal number of human beings. In the inside of the bell are seats for the workmen, with knobs to hang their tools on; and attached to it is a strong double air-pump, which is a mighty improvement on the old-fashioned plan of sinking barrels filled with air. From this pump issues a thick leathern tube, which is closely fitted into the bell, and the length of which can easily be proportioned to the depth of water. As may be supposed, the bell is suspended from a very long crane, the shaft of which is sunk to the very keel of a vessel, purchased and fitted up for the purpose, and which is, in fact, a necessary part of the diving apparatus. On the deck of this vessel is placed the air-pump, worked by our men, with an additional hand to watch the signals. When bout, therefore, to commence operations, the sloop is moved o the outside of the breakwater, the air-pump put in motion, he crane worked, and then go down the aquatic quarrymen. From ts weight and shape, the machine must dip perpendicularly; vhile the volume of air within enables the workmen to breathe, ınd keeps out the water. On arriving at the bottom, the divers are chiefly annoyed with large beds of sea-weed, although, from the inequalities of the channel at Port Patrick, and the partially uneven manner in which the ledges of the bell occasionally rest on the rocks, it is impossible to expel the water altogether; and this, it is presumed, is the reason why it is dangerous to descend in rough or squally weather, when the ıeaving and agitated deep would be apt to dash in at the smallest ranny. To guard against the effects of several hours' partial immersion in water, the men are provided with large jack-boots, caps of wool, and coarse woollen jackets. They also observe the precaution of stuffing their ears with cotton, as the constant stream of air which descends from above, occasions, at first, an uneasy sensation, and is even apt to produce deafness. The chief submarine artist came from Holyhead; and out of 180 masons, carpenters, and labourers, only one man, it is said, volunteered to assist him. A respectable and ingenious gentleman, who had been down in the bell, stated, that he felt no inconvenience whatever; but the air-pump workers, among whom were made some minute inquiries, shook their heads at this piece of information, and hinted, that the volunteer-diver had often felt a little queerish, and, for one thing, "had taken his victuals very badly." Here, then, we have two or three men working with perfect ease and safety 20, 25, and sometimes 30 feet below water. In carrying out the new pier, it is necessary to make a bed for the foundation stones, which would otherwise be left at the mercy of the waves—and this, in a word, is the duty of the divers. With picks, hammers, jumpers, and gunpowder, the most rugged surface is made even, and not only a bed prepared for the huge masses of stone which are afterwards let down, but the blocks themselves strongly bound together with iron and cement. The divers, like other quarrymen, when they wish "to blast," take good care to be put out of harm's way. By means of a tin tube, the powder is kept quite dry, and a branch from the larger cavity, hollow and filled with an oaten straw, is lengthened to the very surface of the water before the fuse is lighted. In one or two cases the powder has failed to explode, and it is very teasing for the men, after three or four hours' hard work below water, to be compelled to descend again, for the sole purpose of repeating the blasting process.

BELLEROPHON, a name sometimes given to the constellation Pegasus.

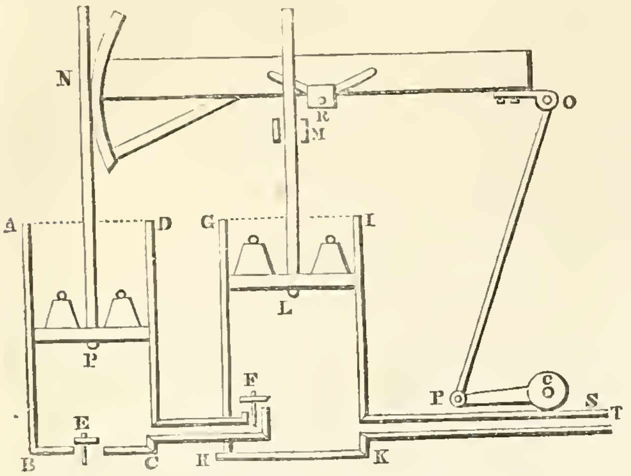
BELLOWS, an instrument constructed for the purpose of alternately drawing and expelling air. In the common culinary bellows the air rushes in at a hole or holes at the bottom, called feeders, over which is a flapping valve, and is expelled through a conical pipe called the nozzle, by means of a kind of mechanism too well known to require description here.

Dr. Gregory observes, that it is not the impulsive force of the blast that is wanted in most cases, but merely the copious supply of air to produce the rapid combustion of inflammable matter; and the service would, in general, be better performed if this could be done with moderate velocities and extended surface. What are called air-furnaces, where a considerable surface of inflammable matter is acted on at once by the current which the mere heat of the expended air has produced, are found more operative, in proportion to the air expended, than blast-furnaces animated by bellows. There is, indeed, a great impulsive force required in some cases; as, for blowing off the scoriæ from the surface of silver or copper in refining furnaces, or for keeping a clear passage for the air in great iron furnaces. But, in general, we cannot procure this abundant supply of air in any other way than by giving it a great velocity by means of a great pressure or impulse; the air is admitted into a very large cavity, and then forcibly expelled from it through a small orifice.

The method of producing a continual blast by a centrifugal force has been long known. Anacharsis, the Scythian, is recorded as the inventor of bellows. But the first bellows acting upon this principle, of which we have a distinct account, is that invented by M. Teral, in 1729, and represented in the following figure, where A B is a cubical box, with a top rather arched: to this box is adapted a hollow pyramidal frustum C, at the extremity of which is the tube or nozzle D; the capacity of the pyramid not being separated from that of the box. This box contains an arbor or shaft carrying vanes, as G F, posited horizontally, and which are here placed, as it were, out of the box, that their shape and number may be seen. The ends of the arbor run in a proper collar on each side of the box, and one end, as F, passes through the side of the box, and carries a pulley: over this pulley passes a cord or band, which also runs round part of a wheel H I, situated at some distance from the bellows, and which is turned by the handle M. Thus it will be manifest, that as this handle turns the wheel H I, it will, by means of the band, turn the pulley F and the arbor and vanes, with a velocity which will be to that of the wheel as the radius of the wheel to that of the pulley. Hence the greater the diameter of the wheel, and the less that of the pulley, the more rapidly will the exterior air (which enters by small holes *h h*, into the top of the box,) be driven by the vanes, and compressed into the truncated pyramid *c*, and thence expelled at D, in a continued blast; which will likewise be the more violent the greater the action at the handle M. This machine, being very simple, is easily constructed, and at a small expense.

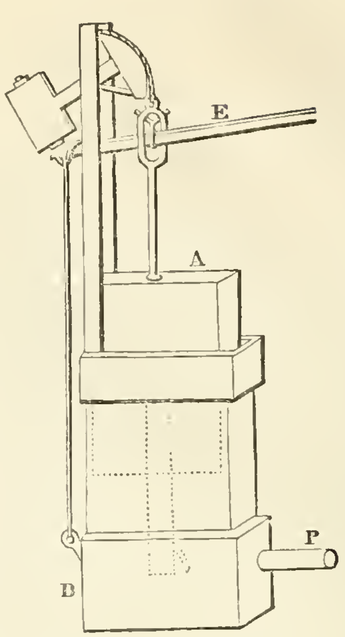


Another bellows, furnishing a uniform blast, is described as follows:—One cylinder is made to deliver its air into another cylinder, which has a piston exactly fitted to its bore, and loaded with a sufficient weight. The blowing cylinder A B C D, (as represented in the figure below,) has its piston P worked by a rod N P. connected by double chains with the arched head of the working beam N O, moving round a gudgeon at R. The other end O of this beam is connected by the rod O P with the crank P Q of a wheel-machine; or it may be connected with the piston of a steam-engine, &c. &c. The blowing cylinder has a valve or valves E in its bottom, opening inwards. There proceeds from it a large pipe C F, which enters the regulating cylinder G H K I, and has a valve at top, to prevent the air from getting back into the blowing cylinder A B C D. It is evident, that the air forced into this cylinder, G H K I, must raise its piston L, and that it must afterwards descend, while the other piston is rising. It must descend uniformly, and make a perfectly equable blast.



We may observe, however, that if the piston L be at the bottom when the machine begins to work, it will be at the bottom at the end of every stroke, if the *tuyere* T emits as much air as the cylinder A B C D furnishes; nay, it will lie a while at the bottom, for, while it was rising, air was issuing through T. But as this would make an interrupted blast, it is prevented thus: The orifice T must be lessened; yet then there will be a surplus of air at the end of each stroke, and the piston L will rise continually, and at last get to the top, and allow air to escape. But it is possible to adjust circumstances, so that neither shall happen. This is done easier by putting a stop in the way of the piston, and putting a valve on the piston, or on the conducting pipe K S T, loaded with a weight a little superior to the intended elasticity of the air in the cylinder. Therefore, when the piston is prevented by the stop from rising, the shifting valve, as it is called, is forced open, the superfluous air escapes, and the blast preserves its uniformity.

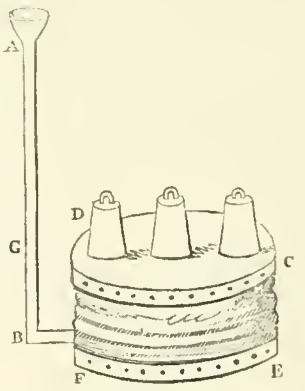
The Hydraulic Forge Bellows, of Mr. J. C. Hornblower, a very ingenious contrivance, is thus described. This invention is shewn in the following engraving:—A the plunger, or working part of the bellows, 18 inches square within, which receives the air by a valve in the hinder part opening inwards, which at the stroke by the rockstaff E throws it down the tube indicated by the dotted lines, which has a valve opening into the reservoir D, whence it is led to the tuyere by the pipe P. Length of the plunger 20 inches, stroke nine inches. Diameter of P three inches; of the nozzle 0·6. The whole is placed in a pit or cistern, having water sufficient to rise to the lower end of the tube where the valve hangs; this tube is the only communication between the upper part and the reservoir D: when as much water is poured in round the working part, over the wash-boards, as will rise within five inches of the upper edge of them, the bellows is ready for use. The little frame-work serves to keep it from rising, and affords a convenient support for the balance and the rockstaff. The area of the pit or cistern ought to be at least twice as much as that of the plunger A.



A very striking difference between the effect of this bellows and a common leathered 30-inch bellows in the same shop, is the following. The leathered bellows throws considerably more air to the fire, and its nozzle, compared with this, is as ·73 to ·60 in diameter, but it does not produce so great an effect in bringing on the heat, and the noise of this is so great as almost to drown that of the common one. The only difference in other respects is, that in the hydraulic bellows the pipe goes under ground for about eight feet, and the conducting pipe of the other comes down about the same distance from the shop above.

When bellows are made more than usually large, for extensive furnaces, they have been frequently worked by water-wheels. But iron furnaces have, of late, been constructed of such magnitude, that no leather bellows could be made sufficiently capacious; and hence large forcing pumps have been substituted for them. We shall, under the article Forge, describe the Carron engine constructed by Smeaton.

Hydrostatic Bellows, (as represented in the annexed figure,) is a machine for illustrating the upward pressure of fluids. It consists of two thick boards E F, C D, about 16 or 18 inches diameter, covered or connected firmly with pliable leather round the edges, to open and shut like common bellows, but without valves; a pipe A B, about three feet high, is fixed into the bellows at B. Now let water be poured into the pipe at A, and it will run into the bellows, gradually separating the boards by raising the upper one. Then, if several weights (3 hundred weights, for instance,) be laid upon the upper board, the water being poured in at the pipe till it be full, will sustain all the weights, though the water in the pipe, should not weigh a quarter of a pound. For the narrower the pipe the better, beyond certain limits, provided we may make it long enough, the proportion being always this:



As the area of the orifice or section of the pipe,
To the area of the bellows' board, E F;
So is the weight of water in the pipe A G,
To the weight it will sustain on the board C D.

For the fluid at B, the bottom of the tube, is pressed with a force varying as its altitude A B; and this pressure is communicated horizontally to all the particles in the space F E, and then distributed equally throughout the fluid in the bellows; consequently, the pressure upwards at F E is equal to the weight of a cylinder of the fluid whose base is F E, and altitude A B; while the actual weight of water borne up is only that of the cylinder, whose base is F E, and height B G; and hence no weights laid upon C D that do not exceed the weight of a cylinder of the fluid, whose base is E F and altitude A G, will disturb the equilibrium.

Bellows, or *Water Blowing-Engine*, is a machine in which the stream of air is supplied by the flowing of the water, and it has been long employed at the iron works of Poullaouen in France. The shower of water, in its descent through the vertical pipe of the machine, carries down a column of air along with it, (upon the principle of the lateral adhesion of fluids,) in the same manner as a shower of rain on the surface of the sea, produces that temporary blast of wind which the seamen term a *squall*. The effects of this machine in producing a blast of air, are inferior to that of the steam-engine; but in situations which afford a plentiful supply and a sufficient fall of water, it may frequently be employed with advantage.

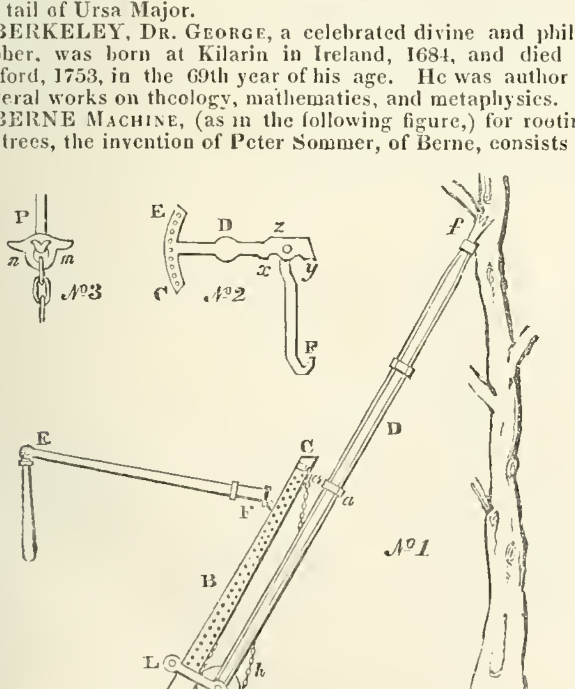
BELTS, *Fascia*, in Astronomy, zones or girdles, surrounding the planet Jupiter, more lucid than the other parts of his body, and terminated by parallel straight lines, being sometimes broader and sometimes narrower, varying both in magnitude and position. Dark spots have frequently been observed in Jupiter's Belts, one of which is permanent, and by means of which the diurnal revolution of this planet has been ascertained. See Phil. Trans. No. 10 and No. 11, vol. lxiii. Some astronomers suppose the belts to be seas, which alternately cover and leave bare vast tracts of this planet; and that the spots are gulfs in those seas, probably as large as our ocean, sometimes full and at others dry. Other hypotheses have been advanced by different astronomers, which, however, are all merely conjectures, and therefore excite but little interest. These belts were first observed at Naples by Zuppi and Bartoli, two jesuits, and afterwards by Campani and Huygens. Cassini observed, also, three dark straight parallel belts on the disc of Saturn; and something of a similar kind has been seen indistinctly on the planet Mars.

BENDING, the reducing a body to a curved or crooked form. The bending of boards, planks, &c. is effected by means of heat, whether by boiling or otherwise, by which their fibres are so relaxed, that they may be bent into any figure at pleasure. Bernoulli has a discourse on the bending of springs or elastic bodies, and Amonton gives several experiments on the bending of ropes.

BENITHNASH. a name sometimes given to the last star in the tail of Ursa Major.

BERKELEY, Dr. George, a celebrated divine and philosopher, was born at Kilarin in Ireland, 1684, and died at Oxford, 1753, in the 69th year of his age. He was author of several works on theology, mathematics, and metaphysics.

BERNE Machine, (as in the following figure,) for rooting up trees, the invention of Peter Sommer, of Berne, consists of three parts, the beam, the ram, and the lever. The beam, A B C, No. 1, of which only one side is seen in the figure, is composed of two stout planks of oak, three inches thick at least, and separated by two transverse pieces of the same wood, at A and C, about three inches thick: these planks are bored through with corresponding holes, to receive iron pins, upon which the lever acts between the two sides of the beam, and which is shifted higher and higher as the tree is raised, or rather pushed out of its place: the sides are well secured at the top and bottom by strong iron hoops. The iron pins on which the lever rests, should be an inch and a quarter, and the holes through which they pass, an inch and a half, in diameter. The position of these holes is sufficiently indicated by the figure. The foot of the beam, when the machine is in action, is secured by stakes represented at G, driven into the earth. The ram, D, which is made of oak, elm, or some other strong wood, is capped with three strong iron spikes represented at *f*, which take fast hold of the tree. This ram is six or eight inches square, and a slit is cut lengthwise through the middle of it, from its lower end at K, to the first ferule *a*, in order to allow room for the chain *g h* to play round the pulley K, which should be four inches thick, and nine inches in diameter. This ram is raised by means of the chain *g h*, which should be about ten feet long, with links four inches and three-quarters in length, and an inch thick. One end of this chain is fastened to the top of the beam at C, while the other, after passing through the lower part of the ram, and over the pulley K, terminates in a ring or link represented in No. 3; the two ears, *m*, *n*, of which, serve to keep it in a true position between the two planks of the beam. In this ring, the hook *p* is inserted: the hook is represented in profile, No. 2, where F is the part which takes hold of the ring. But it must be observed, that the parts of this machine represented in Nos. 2, 3, are drawn on a scale twice as large as the whole engine. The hook F, No. 2, should be made of very tough iron, as well as the handle D, and the arch E C. This handle should be two inches thick at *z*, where it joins to the hook, and the thickness gradually lessen by degrees up to the arch, which need not be more than half an inch thick. On each side of the pin *z* is a semicircular notch *x y*, which rests alternately on the pins when the machine is worked. The hole D, and the arch E C serve to fix a long lever of wood E F, No. 1, by means of two iron pins; and by this contrivance, the lever is either raised or depressed at pleasure, in order to render the working of the machine easy in whatever part of the beam the lever may be placed; for without this contrivance, the extremity of the lever E F would, when the handle is near the top of the beam, be much higher than men standing upon the ground could reach. It must, however, be remembered, that the lever is often shortened by this contrivance, and consequently its power lessened. The machine is worked in the following manner:—It is placed against a tree, in the manner represented in the figure, so that the iron spikes at *f* may have hold of the tree, and the end of the beam A be supported by stakes represented at G. The iron handle, No. 2, is placed in the opening between the two planks of the beam, and the wooden lever fixed to it by means of the iron pins already mentioned. The hook F takes hold of the chain, and one of the iron pins is thrust into the outer row of holes, by which means the outer notch *x* will rest on the pin, which will be now the centre of motion; and the end of the lever E, No. 1, being pressed downwards, the other notch *y*, No. 2, will be raised, and at the same time the chain, and consequently the ram. The other iron pin is now to be thrust into the hole in the inner row, next above that which was before the centre of motion, and the end of the lever E elevated or pushed upwards, the latter pin on which the notch *y* rests, now becoming the centre of motion. By this alternate motion of the lever, and shifting the pins, the chain is drawn upwards over the pulley K, and consequently the whole force of the engine exerted against the tree: there is a small wheel at L, in order to lessen the friction of that part of the machine. From this account the reader will very easily perceive, that the machine is nothing more than a single pulley compounded with a lever of the first and second order. It must, however, be remembered, that as the push of the engine is given in an oblique direction, it will exert a greater or lesser force against the horizontal roots of the tree,



in proportion to the angle formed by the machine with the plane of the horizon, and that the angle of 45° is the maximum, or that when the machine will exert its greatest force against the horizontal roots of the tree.

BERNOULLI, the name of several excellent mathematicians of France and Switzerland.

BERYL, a pellucid gem of a bluish green colour, found in the East Indies, Peru, and Silesia. This gem assumes either the pebble or columnar, or crystal form. To imitate beryl, artists add to 20 lbs. of crystal glass made without magnesia, 6 ounces of calcined brass or copper, and a quarter of an ounce of prepared zaffre.

BIENNIAL PLANTS, are those which endure two years; as, of esculents, the cabbage, savoy, carrots, parsnips, beet, onion, leek; of flowers, carnation, hollyhock, wallflower, &c.

BILBOES, long bars or bolts of iron with skackles sliding on them, and a lock at the end, used to confine the feet of prisoners in a manner similar to the punishment of the stocks. The offender is laid in irons, which are more or less ponderous according to the nature of the offence of which he is guilty.

BILGE, or BILDGE, that part of a floor in a ship which approaches nearer to an horizontal than to a perpendicular direction, and on which the ship would rest if laid on the ground: hence, when a ship receives a fracture in this place, she is said to be bilged, or bulged. Bilge is also the largest circumference of a cask, or that which extends round by the bung-hole.

BILGE-*water*, the rain or sea-water which occasionally enters the lower apartments of a ship, whence running down to the floor, it remains in the bilge of the ship, till pumped out, by reason of her flat-bottom, which prevents it from going to the well of the pump, and is always (if the ship does not leak) of a dirty colour, and disagreeable smell.

BILLION, in Numeration, the sum of a million of millions, or 10000·0000·0000: this term, as well as those of trillion, quatillions, &c. are introduced for the more readily expressing in words, or enumerating, a number consisting of many figures; but they have been differently employed by different writers; the French mathematicians understanding billion to mean thousands of millions, and the English millions of millions; thus, in Bezout's "Course of Mathematics," and the "Encyclopédie Méthodique," the place of billions is said to be the tenth from the right towards the left, whereas we make it in our arithmetics the thirteenth; and it is singular, that this word is not found in any English dictionary. Mr. Bonnycastle, in his arithmetic, uses the phrase bi-million or billion, tri-million or trillion, which seems to be the probable derivation of these terms; and admitting this, there can be no doubt, from analogy, that bi-million or billion means a million times a million, the same as biquadratic means a quantity produced from the multiplication of two quadratics. The French have, however, decidedly the advantage in point of simplicity.

BIMEDIAL LINE, in Geometry, is the sum of two medials. Thus, when two medial lines, commensurable only in power, and containing a rational rectangle, be compounded, the whole shall be irrational with respect to either of the two; and is called, by Euclid, a first *bimedial line*. But if two medial lines, commensurable only in power, and containing a medial rectangle, be compounded, the whole will be irrational; and is called a second *bimedial line*. Euclid, lib. x. prop. 38 and 39.

BINOCLE, or BINOCULAR TELESCOPE, is a telescope to which both eyes may be applied; and, consequently, the same object observed at the same time with both. It consists of two tubes, with two sets of glasses of the same power, and adjusted to the same axis; which has been said to exhibit objects larger and more distinct than a single or monocular glass. But this is probably only an illusion, occasioned by the stronger impression which two equal images, alike illuminated, make upon the eyes. There are also microscopes of the same construction, but they are very seldom used.

BINOMIAL, in Algebra, is a large quantity consisting of two terms or names, and connected by the sign + *plus*, — *minus*, or = *equal*; thus, $a + b$, $a - b$, $a = b$, are all binomials; the difference $a - b$, being also frequently called a *residual*; and by Euclid, *apotome*. The terms binomial and residual are said to have been introduced into algebra by Recorde, in 1557; and they have since been very commonly employed in various ways. Thus we say, *Binomial Curve, Equation, Surd, Theorem*, &c.

BINOMIAL *Theorem*, is a general algebraical expression or formula, by which any power or root of a quantity of two terms is expanded into a series. This is also commonly called the *Newtonian theorem*, or *Newton's binomial theorem*, on account of his being commonly considered as the inventor of it, as he undoubtedly was, at least in the case of fractional and negative indices; which includes all the other particular cases of powers, divisions, &c. This celebrated theorem, as proposed in its simplest form, is this:—Let $a + b$ be raised to the fourth power.

The Powers.	Mode of Expressing them.	Powers Expanded.
Square	$(a+b)^2$	$a^2 + 2ab + b^2$
Cube	$(a+b)^3$	$a^3 + 3^2ab + 3ab^2 + b^3$
4th Power ..	$(a+b)^4$	$a^4 + 4a^3b + 6a^2b^3 + 4ab^3 + b^4$
5th Power ..	$(a+b)^5$	$a^5 + 5a^4b + 10a^3b^2 + 10a^2b^3 + 5ab^4 + b^5$
6th Power ..	$(a+b)$	$a^6 + 6a^5b + 15a^4b^5 + 20a^3b^3 + 15a^3b^4 + 6ab^5 + b^6$.
&c.	&c.	&c.

The first term a is raised to the 6th power, and the second term b to the same power. In all the intermediate terms the powers of a decrease, and the powers of b increase, by unity, in each successive term. In each case, the co-efficient of the second term is the same with the index of the given power. Thus, in the square it is 2, in the cube 3, &c. If the co-efficient of a in any term be multiplied by its index, and the product divided by the number of terms to that place, the quotient will give the co-efficient of the next term.

Thus are we furnished with a general rule for raising the binomial $a + b$ to any power, without the process of actual multiplication. For were we required to raise $a + b$ to the eighth power, the rule just laid down shews us, that

The *first* term is .... a^8

The *second* .... $8a^7b$

The *third* .... $\frac{8 \times 7}{2} a^6b^2 = 28a^6b^2$

The *fourth*.............. $\frac{28 \times 6}{3} a^5b^3 = 56a^5b^3$

The *fifth*................ $\frac{56 \times 5}{4} a^4b^4 = 70a^4b^4$

The *sixth* .... $\frac{70 \times 4}{5} a^3b^5 = 56a^3b^5$

The *seventh* .... $\frac{56 \times 3}{6} a^2b^6 = 28a^2b^6$

The *eighth* .... $\frac{28 \times 2}{7} ab^7 = 8ab^7$

The *ninth* .... $= b^8$.

When the number of terms is even in the resulting quantity, the co-efficients of the two middle terms are the same; and, in all cases, the co-efficients increase as far as the middle term, and then decrease precisely in the same manner, till we arrive at the last term. Guided by this law of the co-efficients, we need only calculate them as far as the middle term, and then set down the remaining ones in an inverted order.

Thus, in $\overline{x-y}$ } The *first* five co-efficients are } 1, 9, 36, 84, 126
} And the *last* five .... } 126, 84, 36, 9, 1.

This rule, exhibited in its most general form of the *Newtonian Binomial Theorem*, is thus read:

Suppose we were required to raise the binomial $a + b$ to *any* power denoted by n: From the principles already laid down, The *first* term would be a^n.

The *second* .... $na^{n-1}b$.

The *third* .... $\frac{n(n-1)}{2}a^{n-2}b^2$.

The *fourth* .... $\frac{n(n-1)(n-2)}{2.3}a^{n-3}b^3$.

The *fifth* .... $\frac{n(n-1)(n-2)(n-3)}{2.3.4.}a^{n-4}b^4$.

The *last* .... b^n.

Or, $$(a+b)^n = a^n + na^{n-1}b + \frac{n(n-1)}{2}a^{n-2}b^2 + \frac{n(n-1)(n-2)}{2.3}a^{n-3}b^3 + \frac{n(n-1)(-2)(n-3)}{2.3.4.}a^{n-4}b^4 + \&c. \ldots\ldots + b^n.$$

By the same process, $$(a-b)^n = a^n - na^{n-1}b + \frac{n(n-1)}{2}a^{n-2}b^2 \frac{n(n-1)(n-2)}{2.3}a^{n-3}b^3 + \&c.;$$ the signs of the terms being alternately + and —.

BIQUADRATIC Root, is the fourth root of any proposed quantity; thus 2 is the biquadratic, or fourth root, of 16. The biquadratic root of a number is found by extracting the square root of it, and then the square root of that root; which last result will be the root sought. Thus, the fourth root of 20736 is found as follows:

$\sqrt{20736} = 144$, the square root,
$\sqrt{144} = 12$, the 4th root sought;

and so on for any other number.

Biquadratic *Equation*, is an equation of the fourth degree, or in which the unknown quantity rises to the fourth power; thus, $x^4 + ax^3 + bx^2 + cx + d = 0$, is a biquadratic equation, in which a, b, c, and d, may be any numbers whatever, positive or negative, or any of them equal to zero or 0.

A biquadratic equation is the highest order of equation that admits of a general solution; all beyond this being resolvable only in particular cases. For the solution of equations of the fourth degree, different solutions have been proposed by several authors.

BIQUINTILE Aspect of the *Planets*, is when they are distant from each other 144°, or twice the fifth part of 360°.

BIRCH, *Bark of*, is used in Russia as we use tiles to cover houses; and among the Indians of America, it covers the slender ribs of their canoes. Birch leaves are of use in the dropsy, itch, &c.

BIRDS, in Heraldry, represent a contemplative or active life, and are emblems of expedition, liberty, readiness, and fear.

Birds. The skeleton or bony frame of birds is lighter than that of quadrupeds, and is calculated for the power of flight; the spine is immoveable, the neck lengthened and flexible; the breast-bone very large, with a prominent keel down the middle, and formed for the attachment of strong muscles. The bones of the wings are analogous to those of the fore-legs in quadrupeds, but the termination is in three joints, of which the exterior one is very short. The legs are analogous to the hind-legs in quadrupeds, and terminate in general in four toes, three of which are commonly directed forwards, and one backwards; in some birds there are only two toes, in others, only three. All the bones in birds are much lighter than in quadrupeds.

The feathers with which birds are covered, resemble the hair of quadrupeds, being composed of a similar substance in a different form. Beneath the general plumage, the skin in birds is covered with a much finer feathery substance, called *down*. The throat, after passing down to a certain distance, dilates into a large bag, answering to the stomach in quadrupeds: it is called the *crop*, and its great use is to soften and prepare the food taken into it, for passing into another receptacle, called the *gizzard*. This powerful stomach consists of two strong muscles, lined and covered with a strong coat furrowed on the inside In the birds of prey, or *accipitres*, this is wanting, the stomach being allied to that of quadrupeds. In this receptacle, the food is ground, and reduced to a pulp. The lungs of birds differ from those of quadrupeds in not being loose in the breast, but fixed to the bones; they consist of a pair of large spongy bodies, covered with a membrane, which is pierced in several places, and communicates with large air-bags, dispersed about the cavities of the body. The eyes of birds are more or less convex in the different tribes; and in general, their sight is more acute than that of most other animals. Their ear, though internal, is constructed very nicely, on the same general plan as in quadrupeds. Their organs of motion are two wings and two legs; and they are destitute of external ears, lips, and many other parts which are important to quadrupeds.

Birds are produced from eggs, which vary in number, size, and colour, but are always covered with a hard shell, and for the most part deposited in an artificial nest, and hatched by the general warmth of the parent sitting upon them.

Linnæus has divided this class into six orders:—1. Accipitres, hawks, &c.; 2. Picæ, pies, &c.; 3. Passeres, sparrows, &c.; 4. Gallinæ, poultry, &c.; 5. Grallæ, herons, &c.; 6. Anseres, geese, &c.

The orders of birds are these:—I. *Land Birds.*—1. Rapacious birds have the upper mandible hooked, and an angular projection on each side near the point, as the eagles, hawks, and owls. 2. Pies, have their bills sharp at the edge, somewhat compressed at the sides, and convex at the top, as the crows. 3. Passerine birds, have the bill conical and pointed, and the nostrils oval, open, and naked, as the sparrow and linnet. 4. Gallinaceous birds, have the upper mandible arched, and covering the lower one at the edge, and the nostrils arched over with a cartilaginous membrane, as the common poultry, turkeys, &c.

II. *Water Birds.*—5. Waders, have a roundish bill, a fleshy tongue, and the legs naked above the knees, as the herons, plovers, and snipes. 6. Swimmers, have their bills broad at the top, and covered with a soft skin; and the feet webbed, as ducks and geese.

Birds, *To Preserve.* The preserving of beautiful birds, with which some foreign countries abound, so as to retain their natural form and position, as well as the beauty of their colours and plumage, must be attended to with great care, lest they should be destroyed by insects, which has often been the case, to the great disappointment of the naturalist. After dissecting all the fleshy parts from the bones, and removing the entrails, eyes, brains, and tongue, the cavities and inside of the skin should be sprinkled with the following antiseptic powder.

Muriate of mercury	2 *oz.*
Calcined nitrate of potass	2
——— sulphate of alumine	2
Sulphur	4
Camphor	2
Pulverized black pepper	8
——— tobacco	8

Mix the whole together, and keep it in a glass vessel, stopped up very close. In Guiana, the number and variety of beautiful birds is so great, that several persons in the colony advantageously employ themselves in killing and preserving these animals for the cabinets of the naturalists in the different parts of Europe. The method of doing this, as related by Mr. Bancroft, is to put the bird which is to be preserved, in a proper vessel, and cover him with high wines, or the first distillation of rum. In this spirit he is suffered to remain for twenty-four or forty-eight hours, or longer, according to his size, till it has penetrated through every part of his body. When this is done, the bird is taken out, and his feathers, which are noways changed by this immersion, are placed smooth and regular. He is then put into a machine made for the purpose, among a number of others; and his head, feet, wings, tail, &c. are placed exactly agreeable to life. In this posture they are all placed in an oven moderately heated, where they are slowly dried, and will ever after retain their natural position, without danger of putrefaction.

To make Pictures of Birds, by Means of their own Feathers.—Get a thin board or panel of deal, or wainscot, well seasoned, that it may not warp. Paste white paper over it, and let it dry. Take any bird you would represent, and draw its outline on the paper in the attitude you desire, and of the full size, adding what landscape, back ground, &c. you wish. This outline, so drawn, is afterwards to be filled up with the feathers from the bird, placing each feather in that part of the drawing corresponding to the part of the bird it was taken from. Cover now the representation with several coats of strong gum water, letting it dry between each coat till it is of the thickness of a shilling. When your ground is thus prepared, take the feathers off from the bird, beginning at the tail or points of the wings, as you must work towards the head. These feathers are prepared by cutting off all the downy part; and the larger feathers have the insides of their shafts pared off, to make them lie flat. To lay them on, use a pair of small pliers to hold them by; and moistening the gummed ground with water, place each feather in its natural and proper situation. Keep each feather down, by putting a small leaden weight upon it, till you have another prepared to lay on. Be careful not to let the gum come through the feathers, as it smears them, and, sticking to the bottoms of the weights, will be apt to pull the feathers off. When you have put on all the feathers, cut a piece of round paper, and colour it like the eye, which you may stick in its place; but the best way is to get eyes made of glass. The bill, legs, and feet, must be drawn and coloured from nature. When it is finished and adjusted to your mind, lay a sheet of paper upon it, and upon that a heavy weight to press it; which must remain till the whole is quite dry.

BISECTION, the division of a quantity into two equal parts.

BISSEXTILE, or LEAP YEAR, in Chronology, a year consisting of 366 days, happening once every four years, by reason of the addition of a day in the month of February, to recover the six hours which the sun spends in his course each year, beyond the 365 days ordinarily allowed for it. The day thus added is also called bissextile; Julius Cæsar having appointed it to be introduced, by reckoning the twenty-fourth of February twice; and as this day, in the old account, was the same as the sixth of the calends of March, which had been long celebrated among the Romans on account of the expulsion of Tarquin, it was called "*bis sextus calendas Martii;*" *i.e.* twice the 6th of the calends of March; and from hence we have derived the name bissextile.

By the statute *de anno bissextile*, 21 Henry III. to prevent misunderstandings, the intercalary day, and that next before it, are to be accounted as one day.

The astronomers concerned in reforming the calendar, by order of Pope Gregory XIII. in 1582, observing that the bissextile in four years, added forty-four minutes more than the sun spent in returning to the same point of the zodiac, and computing that these supernumerary minutes, in 133 years, would form a day; to prevent any changes being thus insensibly introduced into the seasons, directed, that in the course of 400 years, there should be three bissextiles retrenched; so that every centesimal year, which, according to the Julian account, is bissextile or leap year, is a common year in the Gregorian account, unless the number of centuries can be divided by four without a remainder. Thus 1600 and 2000 are bissextile; 1700, 1800, and 1900, are common. But with the exceptions of the above even centuries, any year which exactly divides by four is leap year; and when there is any remainder, it indicates the number of years since leap year.

The Gregorian computation was received in most foreign countries, ever since the reforming of the calendar; and by act of parliament, passed anno 1751, it commenced in all the dominions under the crown of Great Britain in the year following, ordering, that the natural day following the second of September, should be accounted the fourteenth; omitting the intermediate eleven days of the common calendar.

BITTS, a frame composed of two strong pieces of timber, fixed perpendicularly in the fore part of a ship, whereon to fasten the cables as she rides at anchor; in ships of war, there are usually two pair of cable bitts, and when they are both used at once, the cable is said to be double bitted. There are several other smaller bitts; as, the topsail sheet bitts, paul bitts, carrick bitts, &c.

BLACK, an epithet applied to any thing opaque and porous, which imbibes the greater part of the light that falls on it, reflects little or none, and therefore exhibits no colour.

Bodies of a black colour are found more inflammable, because the rays of light falling on them are not reflected outwards, but enter the body, and are often reflected and refracted within it, till they are stifled and lost; and all other circumstances being alike, they are also found lighter than white bodies, being more porous.

A Prussian chemist, (a Mr. Salverte,) in making experiments to improve printers' ink, has discovered a process of producing from hempseed oil, a new species of black pigment, which, for brilliancy and intensity of colour, far exceeds any black known heretofore, and promises to render Prussian black as distinguished a colour as Prussian blue is at present. The inventor has, we understand, not only applied it to improve printers' ink, but also to other useful purposes, particularly as a superior and safe blacking for tanned leather.

The inflammability of black bodies, and their disposition to acquire heat beyond those of other colours, are easily evinced. Some appeal to the experiment of a white and black glove, worn in the same sun; the consequence will be, a very sensibly greater degree of heat in the one hand than in the other. The same thing appears from the phenomena of burning glasses, by which black bodies are always found to kindle soonest; thus a burning glass, too weak to have any visible effect upon white paper, will readily kindle the same paper when rubbed over with ink. Take a large tile, and having whited over one half of its superficies, and blacked the other, expose it to the sun; where having let it lie a convenient time, you will find, that whilst the whited part remains still cool, the black part has grown very hot. For farther satisfaction, leave on the surface of the tile a part retaining its native red, and exposing all to the sun, you will find the latter to have contracted a superior heat in comparison of the white part, but inferior to that of the black. So also on exposing two pieces of silk, one white and the other black, in the same window to the sun, the latter will be considerably heated, when the former has remained cool. Rooms hung with black are not only darker, but warmer than others. Cover the bulb of a thermometer with a black coating of Indian ink, and the mercury will rise several degrees.

BLAGRAVE, JOHN, an eminent mathematician, who flourished about the beginning of the seventeenth century.

BLEACHING, an art which has been cultivated from time immemorial, is divided into two branches; the bleaching of vegetable, and of animal substances. These being of different natures, require different processes for whitening them. Vegetables consist of oxygen, hydrogen, and carbon, of which the latter is in the greatest proportion; animal substances, besides these, contain a large quantity of azote, with phosphorus and sulphur. Hence,

To Bleach Flax and Hemp, which, if examined, will be found to consist of a thin bark, enveloping a green sap, then the fibres or filaments that are used in the making of linen, and within that the woody part. The fibrous part only is used in the making of cloth, and is separated from the other substances, by being first steeped in soft water, until the putrefactive fermentation takes place, with the succulent part, and is taken out of the water as soon as the wood breaks easily between the hands, while it is yet green, and before the whole of its sap is separated. Well water, brackish water, and that which flows over gypseous soil, must be avoided, else the putrefaction will be accelerated, and the texture of the fibres injured. It is thus that a small quantity of salt accelerates animal putrefaction, while a great deal tends to prevent it; and the portion of saline substances held in solution in the water, hastens the corruption of the filaments, which it blackens and spoils. This operation of watering the flax, is tedious and noxious; it destroys the fish in any stream that may be used, and the smell of the putrefying plants is offensive. Modern chemistry shortens this process, and performs it with less risk of injuring the flax, by the following process: If the stream of a solution of caustic alkali in water be introduced into a chamber about thirty feet square, in which the flax is suspended, it will produce the same effect as watering, in less time, with less expenses, and less danger to the flax, which is frequently injured by being too long steeped. Nothing remains after the watering is completed, but the woody part, a hollow tube of compact flax. To separate these stalks, it must be kiln-dried to render it brittle, but too much heat must not be applied. It is next to be beaten or broken, either by manual labour with mallets on wooden anvils, as in the houses of correction, or by mills for the purpose. By this means the flax is divided into small fibres, and most of the wood reduced to small fragments, which are cleared away by scutching or threshing.

Hackling, the last process, is nothing more than combing the flax in small parcels at a time through a pile of polished sharp iron spikes, placed pretty close together, in a wooden board; the first hackle is coarse, the second finer, and the third finer again. The process of hackling divides the fibres of the flax from each other; it detaches the minute fragments of wood which escaped the scutching, and it separates the tow from the short coarse flax. The flax is now ready to be spun into thread or yarn, which is afterwards manufactured into cloth.

To Bleach Linen Cloth.—The linen, as it comes from the loom, is charged with the weaver's dressing, a paste of flour and water, to make it stretch more easily. To discharge this, the linen must be steeped 48 hours in water, till the extraneous substance is decomposed by fermentation. Some bleachers boil the linen in water; but improperly, for paste is not soluble in boiling water. When the linen is well washed and rinsed, after the last process, it is of a grayish white colour, the fibres of which it is composed are naturally very white. And to separate matter that discolours the linen, is the business of bleaching. This gray substance is of a resinous nature, insoluble in water, and from its intimate union with the very fibres of the flax, it is difficult of separation, even by substances that have a solvent power.

Alkaline leys, or solutions of alkali rendered caustic, have the property of dissolving resins, and are employed as menstrua for this purpose. Alone they are not sufficient to complete the process of bleaching. What appears a single fibre of flax in gray linen, is composed of a bundle of minute filaments, closely cemented by the resinous matter: therefore the potash first acts upon the resin of the external coating of the filaments; they are thus loosened or separated, and exposed to the further action of the air. The second boiling of potash opens a second layer, and thus successively layer by layer, till the whole is opened to the centre. If the alkaline solution were sufficiently strong to force its way at once to the centre, it would act upon the filaments, and destroy the texture of the cloth. Each filament, after the alkaline process, retains an impregnation of colouring matter, so intimately united as to resist its further action. This can only be removed by the gradual influence of the atmosphere, according to the old method of bleaching, or by the modern improvement of using oxygenated muriatic acid. To explain the principle by which this latter part of the process is effected, we must consider that the resin, which forms the colouring matter of unbleached linen, is composed chiefly of carbon and hydrogen: this is partly dissolved by the alkaline ley, and what remains becomes united to the oxygen of the atmosphere, flying off in the state of carbonic acid gas, or remaining as water. The old manner of bleaching was tedious, two or three months being necessary to give the cloth its pure whiteness. The simplicity of the process, however, and the scanty apparatus it requires, recommends it to people who make their own cloth, particularly in Scotland and Ireland.

The method of bleaching by the action of the atmospheric air is this:—After steeping the linen as mentioned above, to remove the weaver's dressing, the pieces of cloth are dried, and then submitted to the operation of bucking. For this purpose a ley is prepared, by dissolving a quantity of potash* in soft water, to which some soap is added. This liquor is heated to about 100 degrees, and poured upon the linen. After the cloth is well down in the ley, it is drawn off, heated a little higher, and again poured upon the linen. This operation is repeated at successive intervals, allowing the ley to remain longer each time, moderately increasing the heat for about six hours. The cloth is then left steeping for about four hours, when it is taken out, rinsed, and carried to the fields, where it is spread upon the grass, and secured by pins; water is sprinkled on it to keep it moist for some hours. After it has lain half a day, the watering is less frequent, and at night it is left to the dews. On the succeeding days it is watered three or four times, if the weather be dry, and then it remains on the field till the air seems to have little effect in whitening. It is then brought back to the coppers, and bucked again with a ley somewhat stronger than the last, rinsed, and again spread in the field. It is thus alternately bucked and watered from ten to fifteen times, according to the state of the weather, making the bucking stronger and stronger, till about the middle, and then weaker and weaker till towards the conclusion of the operation. It must now be soured, or steeped, in some acid liquor. The acid which has been usually employed for souring, is formed by the fermentation of bran and water; sour whey has sometimes been used. But sulphuric acid very much diluted, has been found more convenient, and not more injurious. The cloths are kept in the souring for about six days, if the liquor be formed of milk or bran, or a less time when sulphuric acid is used. They are then rubbed with soap, particularly the selvages, as these resist most the action of the air. It is again bucked, rinsed, watered, and exposed to the atmosphere, and these processes are successively repeated, till the linen has acquired its proper degree of whiteness.

To bleach by the oxygenated muriatic acid.—The oxygenated muriatic acid is only a combination of muriatic acid and oxygen. All vegetable colours are influenced by this acid, and whitened with more or less celerity; the colouring matter undergoes a real but slow combustion, which terminates by the formation of carbonic acid gas, that escapes into the atmosphere. In whatever manner the oxygenated muriatic acid is procured, the oxygen adheres to it very weakly, and upon this property depends the possibility of producing speedily, in manufactories, that action of bleaching which the atmosphere produces slowly. The method of bleaching by oxygenated muriatic acid was quickly and successively introduced into the manu factories of Manchester, Glasgow, Rouen, Valenciennes, and Courtray; and it has since been generally adopted in Great Britain, Ireland, France, and Germany. The advantages that result from this method, which accelerates the process of whitening cottons, linens, paper, &c. to a really surprising degree, in every season of the year, can be justly appreciated by commercial people only, who experience its beneficial effects in many ways, but particularly in the quick circulation of their capitals. To save the expense of first preparing the muriatic acid, you may mix with the oxyde of manganese, muriate of soda, or common salt, and sulphuric acid diluted with water. The sulphuric acid acts upon the salt, and disengages from it the muriatic acid, which is oxygenated by the oxyde of manganese. The proportions observed, when cotton is the article to be bleached, are, manganese, 30 parts; common salt, 80; sulphuric acid, 60; water, 120. For linen-cloth, the proportions are as follow: manganese, 60 parts; salt, 60; sulphuric acid, 50; water, 50. The better these substances are combined, the more easily will the acid gas be disengaged by the action of the sulphuric acid.

To ascertain the strength of the acid for bleaching, a solution of indigo in the sulphuric acid is employed. The colour of this is destroyed by the oxygenated muriatic acid, and, according to the quantity of it that can be discoloured by a given quantity of the liquor, its strength is determined. Cloth is prepared for immersion in oxygenated water, by first soaking it in a ley of weak potash, and rinsing it afterwards in water, to free it completely from the weaver's dressing, and the saliva of the spinners. In this country, machinery is employed for rinsing and beating; the apparatus must be arranged according to the objects to be bleached; the skeins of thread suspended in the tub destined for them, and the cloth rolled upon reels in the apparatus. When every thing is thus disposed, the tubs are filled with oxygenated muriatic acid, by introducing a funnel, which descends to the bottom of the tub, in order to prevent the dispersion of the gas. The cloth is wound, or the frame-work on which the skeins are suspended is turned several times, until, by taking out a small quantity of the liquor from time to time, and trying it by the test of the solution of indigo, it is judged that it is sufficiently exhausted. The weakened liquor is then drawn off, and may be again employed for another saturation. Experience proves that the use of the oxygenated muriatic acid alone weakened the cloth, and various methods of preventing its noxious effects upon the health of the workmen were tried, till it was discovered that an addition of alkali to the liquor destroyed its suffocating effects, without injuring its bleaching powers. The process began then to be carried on in open vessels, and has since been continued in this manner. The bleacher is now able to work his pieces in the liquor, and to expose every part of them to its action, without risk or inconvenience.

---

* It is most economical to render it caustic for the purpose of bleaching. This is done by adding quicklime to the mild potash, the former having a stronger affinity for the carbonic acid than the latter. But care must be taken not to use the alkali too strong.

Potash was at first used for this purpose; and although this advantage was unquestionably great, it was diminished by the heavy expense of the alkali, which was entirely lost. It was afterwards discovered that the oxymuriatic acid might be combined with the alkaline earths, as lime and barytes, and also with magnesia, by this means forming oxymuriates, which were soluble in water, and had the property of bleaching. The oxymuriate of lime is at present used in almost all the bleaching grounds. If the oxygenated acid be passed through lime water, it combines with the lime, and forms oxymuriate of lime; but as the water can only retain a small portion of lime, to cause a larger quantity of lime to combine with the oxymuriatic acid gas, the lime must be mechanically suspended in the water, into which the gas is made to pass, and agitated, so as to present fresh matter to the gas. By this means the oxymuriate of lime is dissolved in water, and used as a bleaching liquor preferable to the oxygenated muriatic acid and potash. At the great bleach-fields in Ireland, four leys of potash are applied alternately with four weeks' exposure on the grass, two immersions in the oxygenated muriate of lime, a ley of potash between the two, and the exposure of a week on the grass, between each ley and the immersions. During summer, two leys, and fifteen days' exposure, prepare cloth for the action of the oxygenated muriate; then three alternate leys, with immersions in the liquor, complete the bleaching, and nothing then will be necessary, but to wind the cloth through the sulphuric acid. The oxygenated muriatic acid gas may also be combined with lime in a dry state, or the water may be evaporated when it is employed for the formation of oxymuriates, which may then be very conveniently transported to any distance without injury to its detersive power.

The sulphuret of lime, or the combination of sulphur and lime, which are both cheap articles, answer the purposes of potash in bleaching; it is useful in some cases, in others it will not supersede the use of alkali. To prepare the sulphuret of lime for the purpose of bleaching: Take sulphur of brimstone, in fine powder, four pounds; lime, well slaked and sifted, twenty pounds; water, sixteen gallons; mix these well, and boil them for half an hour in an iron vessel, stirring them briskly. Soon after the agitation of boiling is over, the solution of the sulphuret of lime clears, and may be drawn off free from the insoluble matter, which rests upon the bottom of the boiler. The liquor, in this state, is of the colour of small-beer, but not so transparent. Sixteen gallons of fresh water are afterwards poured upon the insoluble dregs in the boiler, to separate the remaining sulphuret from them. When it clears, it is drawn off, and mixed with the first liquor; to these again thirty-three gallons more of water may be added, which will reduce the liquor to a proper standard for steeping the cloth. Thus you have sixty gallons of liquor from four pounds of brimstone. When linen has been freed from the weaver's dressing, in the manner already described, it is to be steeped in the solution of sulphuret of lime (prepared as we have described) for about twelve or eighteen hours, then it is to be taken out and well washed. When dry, it is to be steeped in the oxymuriate of lime for about fourteen hours, and then washed and dried. To whiten the linen, this process is to be repeated during six alternate immersions in each liquor.

The rationale of these processes is the following: The oxygenated liquor supplies to the cloth the place of the atmospheric air, and this in greater abundance, and in a state which renders its action on the cloth more expeditious and more complete. By the union of the oxygen with the carbon of the cloth, carbonic acid is formed, and flies off; and the cloth becomes white.

To bleach by steam.—As the action of steam alone does not bleach, the concurrence of oxygen is necessary to aid the composition of the carbonic acid; for this acid requires for its formation, 28 parts of carbon, saturated with 72 of oxygen; but all the oxygen in the apparatus would not be sufficient to saturate the colouring matter burnt by the alkaline combustion, and converted into carbon; this deficiency is supplied by immersion in any oxygenated liquor whatever, and the dispersion of the elastic fluid thus formed is then facilitated by exposure on the grass. To bleach cloth in this manner, it must be immersed in a slight alkaline caustic liquor, and placed in a chamber constructed over a boiler, into which is put the alkaline ley which is to be raised into steam. After the fire has been lighted, and the cloth exposed to the action of the steam for a sufficient time, it is taken out, and immersed in the oxygenated muriate of lime, and afterwards exposed for two or three days on the grass. This operation, which is very expeditious, will be sufficient for cotton; but if linen cloth should still retain a yellow tint, a second alkaline caustic vapour bath, and two or three days on the grass, will be sufficient to give it the necessary degree of whiteness. For the use of private families, when the linen is dirtied by perspiration or grease, laundresses would do well to steep it for some time in clear water, made by mixing one quart of quicklime in ten gallons of water, letting the mixture stand twenty-four hours, and then using the clean water drawn from the lime. This whitens beautifully without injuring the cloth. The linen in many families is all washed in this manner. It is to be washed as usual, but will require much less soap to be used.

To bleach Cotton, requires not the same preparations as hemp and flax. The first operation is scouring it in a slight alkaline solution, or by exposure to steam. It is afterwards put in a basket, and rinsed in running water. The immersion of cotton in an alkaline ley, how well soever it may be rinsed, always leaves with it an earthy deposit. Cotton bears the action of acids better than hemp or flax; and time is even necessary before their action can be prejudicial to it. Hence, by pressing it down in a very weak solution of sulphuric acid, and afterwards renewing the acid by washing, lest, remaining too long in it, the cotton should be destroyed; all the earthy matter is removed from it.

To bleach Wool.—Wool is a kind of hair, with which the bodies of some animals are covered, and is composed of filaments or tubes, filled with an oily or medullary substance. The sides of these tubes are perforated with a multitude of small pores, which communicate with a longitudinal tube. By chemical analysis, wool gives a great deal of oil, and carbonate of ammonia; caustic alkaline leys dissolve it entirely. It undergoes no change in boiling water; and scarcely alters when preserved in a place well aired; acids have very little action on it; and when exposed to a strong heat, it enters into fusion. The little action which acids have upon wool, and its unalterableness in water, even when aided by heat, render it necessary to have recourse to alkaline or saponaceous leys; but its solidity in these salts shews, that great prudence and caution must be employed in their use. In regard to acids, none have been hitherto used but sulphureous acid, obtained in the gaseous state by combustion.

In the preliminary operations to which wool is subjected, a little of its grease is left, to secure it from insects. Wool is often freed from the grease by farmers, who wish to sell it at a high price; but in the subsequent manipulations, it is greased before it is combed and spun, and as this fat matter attracts dust, it dirties and thickens the stuffs. The first kind of bleaching wool receives, frees it from these impurities. This operation, called scouring, is generally performed by means of an ammoniacal ley, formed of five measures of river water and one of stale urine; the wool is immersed for about twenty minutes in a bath of this mixture, heated to fifty-six degrees; it is then taken out, suffered to drain, and then rinsed in running water: this process softens the wool, and gives it the first degree of whiteness; it is thrice repeated, after which the wool may be employed. In some places, scouring is performed with water slightly impregnated with soap; and indeed, for valuable articles, this is the preferable process, but it is expensive for articles of less value.

Fulling the cloth adds still to the whiteness; and, if an increased degree be necessary, it may be procured by the action of the sulphureous acid; or of the fumes of sulphur in a state of combustion, or the vapour of that acid condensed and combined with water.

Sulphuring is performed in an arched chamber, constructed in such a manner, that the articles exposed to the action of the sulphur can be suspended. The chamber being filled, a certain quantity of sulphur is placed in it in a state of combustion, in flat dishes, the entrance is shut, and all the interstices around the door stopped, to prevent the access of the atmospheric air. The acid, generated by the combustion of the sulphur, penetrates the stuffs, attacks and destroys the colouring matter, and effects the bleaching. The stuffs are left in the stoves from six to twenty-four hours afterwards. They are then taken out, and passed through a slight washing with soap, to remove the roughness they have acquired by the action of the acid, and to give them the necessary softness. But then this process is imperfect. At first, the acid of the sulphur acts only on the surfaces, and does not penetrate. This aerial immersion is not sufficient; the gas cannot introduce itself to a sufficient depth into the stuffs, and the superficies only is whitened.

A superior method has been invented, which is, by making use of sulphureous acid; which is generated by the imperfect combustion of sulphur, and differs from the sulphuric acid, (oil of vitriol,) by containing less of the acidifying principle. It is the mean between sulphur and the sulphuric. Sulphureous acid gas unites easily with water, and in this combination is employed for bleaching wool or silk. The sulphureous acid in this liquid state, may be prepared by passing it through water in an apparatus nearly similar to that used for preparing oxygenated muriatic acid. The cheapest method of obtaining it, is to decompose sulphuric acid by the mixture of some combustible capable of taking from it parts of its oxygen. In experimental chemistry, it is obtained by means of metallic substances with great purity, and particularly by mercury; but for bleaching, and where great economy is required, we would recommend the most common substances, and the following process. Take chopped straw, or saw-dust, and introduce it into a mattress; pour over it sulphuric acid, applying at the same time heat, and there will be disengaged sulphureous acid gas, (vapour of sulphur,) which may be combined with water in the apparatus. The pieces are rolled upon reels, and drawn through the sulphureous acid, by turning them, until the whiteness is sufficiently bright. They are then taken out, and drained on a bench covered with cloth, lest they should be stained by the decomposition of the wood and the sulphureous acid. They are next washed in river water, and Spanish white is employed, if necessary. This operation is performed by passing the pieces through a tub of clear water, in which eight pounds of Spanish white have been dissolved. To obtain a fine whiteness, the stuffs are twice sulphured. This process is completed in one immersion, and a reeling of two or three hours.

To azure or blue the cloth, you throw, into the Spanish white liquor, a solution of one part of Prussian blue to 400 parts of water; shake the cloth in the liquid, and reel it rapidly. Then, by a slight washing with soap, to give softness and pliability to the stuffs, the operation is terminated. The final operations of drying, stretching, pressing, &c. have all been illustrated in what has been said of dyeing and bleaching linen; for the directions vary so little in both, that it would be but a repetition to detail here what the reader is already acquainted with.

To bleach Silk.—Silk is a semi-transparent matter, spun by a caterpillar, and formed of a substance contained in its body, which becomes hard in the air. The filaments, prepared by the silk-worm, are rolled up in a ball, and in this state it is covered with a yellow varnish, that destroys its brilliancy, and renders it tough. By chemical analysis, silk gives carbonate of ammonia and oil; boiling water produces no effect upon it; alcohol makes it experience no change, but concentrated alkaline leys attack and dissolve it. To give splendour to silk, it must be freed from its varnish. This covering is soluble in alkaline leys. Silk is usually scoured by soap, when it loses one-fourth of its weight. The matter disengaged has a fetid smell, and if the silk be not rinsed in plenty of water putrid fermentation takes place. Even the least soap injures the whiteness of the silk. This is proved by the fact, that the splendour of the Chinese silks is brighter than that of the European; and the Chinese employ no soap in their operations. A slightly alkaline ley will dissolve the varnish of the silk without using soap; and this has also been effected by the action of boiling water at a very high temperature.

The following method has been used very successfully in France. Take a very weak solution of caustic soda, and fill with it the boiler of the apparatus for bleaching with steam. Charge the frames with skeins of raw silk, place them in the apparatus until it is full; then close the door, and make the solution boil. Having continued the ebullition for twelve hours, slacken the fire, and open the door of the apparatus. The heat of the steam, which is always above 250 degrees, will have freed the silk from the gum, and scoured it. Wash the skeins in warm water, wring them, place them again on the frame in the apparatus, and make the whole boil a second time. Wash them now several times in water, and immerse them in soapy water to give them softness. But the whiteness which silk acquires by these operations, is carried to a higher degree of splendour by exposing the material to the action of sulphureous acid gas, in a close chamber, or by immersing it in sulphureous acid, as we have explained for whitening wool.

To bleach Prints, and printed Books.—The new mode of bleaching has been applied to the whitening of books and prints that have been soiled by smoke and time, and therefore it will be proper that we here explain this process. To whiten an engraving, immerse it in oxygenated muriatic acid, letting the article remain in it a longer or shorter space of time, according to the strength of the liquid. To whiten the paper of a bound book, all the leaves must be moistened by the acid, and therefore care must be taken to open the book, and making the boards rest on the edge of the vessel, so that the paper alone shall be dipped in the liquid: the leaves must be separated from each other, to be equally moistened on both sides. In the same proportion as the liquor assumes a yellow tint, the paper becomes white. In about three hours, the book must be taken from the acid liquor, and the leaves plunged into pure water, with the same care and precaution as recommended in regard to the acid liquor, so that the water touch only the two surfaces of each leaf. The water must be renewed every hour, to extract the remaining acid, and dissipate the unpleasant smell. By this process, there is, however, some danger that the pages may not be all equally white, either because the leaves have not been sufficiently separated, or because the liquid has had more action on the exterior margins than those near the binding. The best way is to destroy the binding, and each leaf will thereby receive an equal and perfect immersion; this second process is thus described by Chaptal.

"They begin," says he, "by unsewing the book, and separating it into leaves, which they place in cases formed in a leaden tub, with very thin slips of wood, or glass, so that the leaves, when laid flat, are separated from each other by intervals scarcely sensible. The acid is then poured in, making it fall on the sides of the tub, in order that the leaves may not be deranged by its motion. When the workman judges, by the whiteness of the paper, that it has been sufficiently acted upon by the acid, it is drawn off by a cock at the bottom of the tub, and its place is supplied by clear fresh water, which weakens and carries off the remains of the acid, as well as the strong smell. The leaves are then to be dried, and after being pressed, may be again bound up.

"The leaves may be placed also vertically in the tub: and this position seems to possess some advantage, as they will be less liable to be torn. With this view I constructed a wooden frame, which I adjusted to the proper height, according to the size of the leaves which I wished to whiten. This frame supported very thin slips of wood, leaving only the space of half a line between them. I placed two leaves in each of these intervals, and kept them fixed in their place by two small wooden wedges, which I pushed in between the slips. When the paper was whitened, I lifted up the frame with leaves, and plunged them to remove the remains of the acid, as well as the smell; this process I prefer to the other.

"By this operation books are not only cleaned, but the paper acquires a degree of whiteness superior to what it possessed when first made. The use of this acid is attended also with the valuable advantage of destroying ink spots. This liquor has no action upon spots of oil or animal grease; but it has been long known that a weak solution of potash will effectually remove stains of that kind.

"When I had to repair prints so torn that they exhibited only scraps pasted upon other paper, I was afraid of losing these fragments in the liquid, because the paste became dissolved. In such cases I enclosed the prints in a cylindric glass vessel, which I inverted on the water in which I had put the mixture proper for extricating the oxygenated muriatic acid gas. This vapour, by filling the whole inside of the jar, acted upon the print; extracted the grease as well as ink spots; and the fragments remained pasted to the paper."

To prepare Oxygenated Muriatic Acid by an easy Method.—To oxygenate the muriatic acid, dilute it, and mix it in a very strong glass with manganese, so that the mixture may not occupy the whole contents of the glass. Air bubbles are formed on the surface of the liquor; the empty space becomes filled with a greenish vapour; and at the end of some hours the acid may be farther diluted with water, and then used. It will have an acid taste, because the whole has not been saturated with oxygen; but it will possess the qualities of the oxygenated muriatic acid. This process may be adopted when there is not time to set up an apparatus for distilling, to procure the oxygenated acid.

To bleach Paper.—The oxygenated muriatic acid has also been applied to bleach paper, being more expeditious. If we were to bleach old printed papers, to be worked up again, we must boil them for an instant in a solution of soda, rendered caustic by potash. Then steep them in soap-water, and then wash them, after which the whole may be reduced to a pulp by the paper-mill.

To bleach old written papers to be worked up again, we steep them in a cold solution of sulphuric acid in water, after which we wash them before they are taken to the mill. The acidulated water will be the more effectual if it be heated.

To bleach printed papers without destroying the texture of the leaves, we steep the leaves in a caustic solution of soda, and afterwards in one of soap. Then we arrange the sheets alternately between cloths, just as paper-makers dispose their sheets of paper when delivered from the form. The leaves must then be put in a press, and they will become whiter, unless they have been stained with printers' ink or size. If one operation should not completely effect the whitening of the leaves, you must repeat the process till it is effectual.

To bleach coloured rags to make white paper, we macerate the rags—then put them into a solution of caustic alkali, and next into the oxygenated muriatic acid;—lastly, they are to be steeped in diluted sulphuric acid.—These processes of bleaching have been classed under one general title, though the manufacture of paper has not been treated in conjunction with them.

To remove Ink Stains.—Apply to the stain muriatic acid diluted in six times its weight in water, and after a minute or two wash it off; the application should be repeated as often as may be found necessary. The vegetable acids equally effectual are attended with less risk. A solution of the oxalic, citric, (acid of lemons,) or tartareous acids, in water, may be applied to the most delicate fabrics without danger or injury; and the same solutions will discharge writing, but not printing ink. They may be therefore employed in cleaning books defaced by writing on the margin. Lemon, and sorrel juice, will remove ink stains, though not so easily as the concrete acid of lemons or citric acid.

To remove Iron Stains.—Ink stains, on the application of soap, are changed into iron stains. But the real iron stains are occasioned by the cloth coming in contact with iron, or its oxyde. Both may be removed by diluted muriatic acid, or by the acid of lemons. When suffered to remain long on cloth, they are taken out with difficulty, because the iron, by repeated moistening with water, and exposure to the air, acquires such an addition of oxygen, as renders it insoluble in acids; yet these spots may be discharged, by applying first a solution of an alkaline sulphuret, which must be well washed from the cloth, and afterwards a liquid acid. The sulphuret, in this case, extracts part of the oxygen from the iron, and renders it soluble in diluted acids.

To remove the stains of fruit and wine, prepare a watery solution of the oxygenated muriatic acid, or oxygenated muriate of potash or lime, to which a little sulphuric acid has been added. Steep the stained spot in one of these solutions till it is discharged; the solution can only be applied to white goods, for the uncombined oxygenated acid discharges printed and dyed colours. The oxygenate acid is easily applied by persons who have not the apparatus for saturating water with the gas, thus:—Put a table-spoonful of muriatic acid (spirit of salt) into a teacup, and add to it about a tea-spoonful of powdered manganese; set this cup in a larger one filled with hot water; moisten the stained spot with water, expose it to the fumes which arise from the teacup, and if the exposure be continued a sufficient length of time, the stain will disappear entirely.

To remove spots of grease from cloth, take a diluted solution of potash, which must be cautiously applied, to prevent injury to the cloth. Stains of white wax, from wax candles dropping upon the cloths, are removed by spirits of turpentine, or sulphuric ether, which will also take out the marks of white paint.

To take spots of grease out of books, prints, or paper, warm the stained paper gently, and take out as much of the stain as possible by means of blotting paper; then dip a small brush in essential oil of turpentine, heated almost to boiling, (when cold, it acts weakly,) and draw it gently over both sides of the paper, which must be carefully kept warm. Repeat this operation as often as the spot imbibed by the paper, or its thickness, may render necessary. When the greasy substance has been removed, the paper may be restored to its former whiteness by the following method. Dip another brush in highly rectified spirit of wine, and draw it over the place which was stained, and particularly round the edges, to remove the border that would still present a stain. By employing these means with caution, the spot will disappear, and the paper will resume its original whiteness. Should the process be employed on a part written with common ink, or printed with printers' ink, it will experience no alteration whatever.

BLOCK MACHINERY. The machinery for manufacturing ship's blocks in the royal dockyard at Portsmouth, invented by Brunel, and adjusted in all its parts by the elaborate and ingenious calculations of Dr. Gregory, of the Royal Military Academy, Woolwich, who gives the following account of this apparatus, in vol. II. of his Mechanics, is greatly and deservedly celebrated:

The machines devoted to this purpose have been separated into four classes. 1. The sawing machine for converting the large timber into proper dimensions for the small machines to operate upon. 2. Those machines which are employed in forming the sheaves. 3. Those which form the iron pins for the blocks. 4. Those by which the shells of the blocks are manufactured. They are all worked by means of two steam-engines, each of thirty-horse power. Either of these can be applied indifferently to work the chain pumps, or for turning the wood-mill; and their power is transmitted by a train of wheel-work, to a horizontal shaft, extending along the centre of the middle building, very near its roof. Upon this are a number of wheels and drums, which, by endless ropes and straps, communicate motion to the several subordinate machines.

The order of the processes is this. The elm trees are first cut into short lengths, proper to form the various sizes of blocks, by two large sawing machines, one a *reciprocating*, the other a *circular* saw. These lengths of the trees are next cut into squares, and ripped or split up into proper sizes by four sawing benches with circular saws, and one very large reciprocating saw, which is employed for cutting up the pieces for very large blocks.

The scantlings, thus prepared for the blocks, are perforated in three boring machines, with a hole through each to contain the centre pin for the sheaves of the block, and as many other holes in a direction perpendicular to the former, as the number of sheaves it is to have; these holes being intended as the commencement of the several mortises to contain the sheaves.

The blocks are next mortised in three mortising engines, which elongate the holes abovementioned to their proper dimensions. Here the motion of the sliding frame for the chisels, is communicated to it by means of a long working beam or lever, extending the whole length of the frame at the top of it. At one end it is united by a connecting rod with the chisel frame; and at the other it is fixed to an axis, which is supported by the framing, and which forms its centre of motion. A connecting rod is joined to it in the middle of the beam; the lower end of which is worked by a crank, formed in the middle of the main axis, which is situated in a direction perpendicular to that which we have described, and is supported in the framing. It is provided with a cone for casting off the movement. The engine with the beam acts with surprising rapidity, making upwards of 400 strokes per minute, at every one of which it cuts out a chip from each mortise as thick as pasteboard. Its movement is, indeed, so rapid, that the chisels cannot be distinctly seen when it is at work; so that the mortises seem to lengthen, and chips to fall out, without any evident cause.

The angles of the blocks are next cut off by three circular saws, as preparatory to reducing them to the elliptical figure.

The outside surfaces of the block are then formed to their true figure by three shaping-engines, each of which forms every part of ten blocks simultaneously. The scores, or grooves, round the block are next formed, to receive the rope or strap by which they are suspended; this is effected by two scoring-engines. Then the blocks are trimmed by manual labour, to smooth and polish them.

In order to make the sheaves, the first process is cutting pieces or flakes off the end of the trees of lignum vitæ, of a suitable thickness to form the sheaves. This is accomplished by a reciprocating and two circular saws. These flakes are made circular, and the centres pierced in two rounding and centering machines, or trepan saw.

A hole is next excavated in the centre of each sheave, to inlay the coak or piece of bell metal, which is fitted into the centre of each sheave, to form a socket for the centre pin. The centre holes through the coaks are next broached out to a true cylinder in three broaching-machines.

The last process is turning the faces and edges of the sheaves to a flat surface, in three facing lathes, which also form the grooves round the edges for them, for the rope which encompasses them when in the block. There are also two machines for making *dead eyes*, which are both ingenious and complete. The whole number of machines is thirty-seven.

Blocks are used for various purposes in a ship, either to increase the mechanical power of the rope, or to arrange the ends of them in certain places on the deck, and they may be readily found when wanted; they are consequently of various sizes and power, and obtain various names, according to their form or situation, thus:

A *Single Block*, contains only one sheave or wheel. A *Double Block*, has two sheaves. A *Long Tackle Block*, has two sheaves, one below the other. A *Snatch Block*, is a single block with an opening on one side, in which the bite of a rope may be laid instead of reeving the end through, which, in some circumstances, would be very inconvenient. The *Spring Block*, an invention of Hopkinson, of Philadelphia, calculated to assist a vessel in sailing, and particularly intended by him to be applied to the sheets and the dead-eyes; it is composed of a common block or dead-eye, attached to a spiral spring of well tempered steel, within the cavity of which is a chain of suitable strength, called a check-chain; when the spring is not in action, this chain is slack; but, when the spring is extended by the force of the wind as far as it may be without injury, the check-chain begins to bear, and prevents its farther extension. *Top Block*, is a large single block with an iron strop and hook, by which it is hung to an eye-bolt in the cap, and is used to sway up or lower down the topmasts. *Jear Blocks*, are twofold or threefold blocks, applied to hoist or lower the main and fore yards. *Viol Block* or *Voyal Block*, is a large block through which the voyal or messenger passes when the anchor is weighed by the fore or jear capstan. *Clue-garnet* and *Clue-line Blocks*, are distinguished from others by having shoulders upon their upper parts, through which the strop is laid, and is applied to draw up the clues or lower corners of the square sails to their respective yards. *Cat Block*, is a two or three fold block, with an iron strop and large hook to it, and is employed to draw the anchor up to the cathead.

Every block is composed of three, and generally four, parts: 1. The shell, or outside wooden part. 2. The sheave, or wheel, on which the rope runs. 3. The pin, or axle, on which the sheave turns. 4. The strop, or part by which the block is made fast to any particular station, and is usually made either of rope or of iron. *Iron-stropped Blocks*, frequently have the hook working in a swivel in order to turn it, that the several parts of the rope of which the tackle is composed, may not be twisted round each other, which would greatly diminish the mechanical power.

Block and *Block*, is the situation of a tackle when the blocks are drawn close together, so that the mechanical power becomes destroyed till the tackle is again overhauled by drawing the blocks asunder.

BLONDEL, Francis, a celebrated French mathematician and military engineer, was born in Picardy in 1617, and died in Paris in 1686. He was author of two distinct works on architecture, and another on fortification; besides which, he published "A Course of Mathematics," "The Art of throwing Bombs," and several ingenious pieces in the Memoires of the French Academy of Sciences, particularly in the year 1666.

BLOOD, *Circulation of the.* About the year 1600 Mr. Harvey, an English physician, discovered the process (if we may so call it) of the circulation of the blood; to form a distinct notion of which, it will be necessary to describe the structure of the arteries, veins, and nerves; and principally the cavities of the heart, by means of which the blood is propelled through the body. To these we now proceed:—

The arteries are blood-vessels consisting of a close texture of strong elastic fibres, woven in various webs, laid in different directions, and interspersed with an infinity of delicate nerves, veins, and minuter arteries. They are divided and subdivided into numberless branches and ramifications, that become smaller and smaller as they recede from the heart, until at last their extremities are found much more slender than the hairs of our heads, (and are therefore called capillary arteries,) which either unite in continued pipes with the beginnings of the veins, or terminate in small receptacles, from which the veins derive their origin. The arteries have no valves, but only have their trunks spring from the heart: they throb and beat perpetually whilst life remains; their extremities differing in the thickness of their coats and some other particulars, according to the nature of the part which they pervade. All the arteries in the lungs (except the small ones that convey nourishment to them) are derived from the great pulmonary artery, which issues from the right ventricle of the heart. And all the arteries in the rest of the body proceed from the aorta, (which obtained this name, because the ancients thought it contained air only,) whose trunk springs from the left ventricle of the heart.

The veins resemble the arteries in their figure and distribution; but their cavities are larger, and their branches, perhaps, more numerous. Their coats are much weaker and more slender than those of the arteries. They are furnished with several valves, contrived in such a manner as to permit the blood to pass freely from the smaller into the larger branches, but to stop its retrogression. They neither throb nor beat. Their beginnings form continued pipes with the extremities of the arteries, or arise from some gland or receptacle where the arteries terminate. All the veins in the lungs, from their capillary beginnings growing still larger, unite at last, and discharge their blood into the left auricle of the heart: and all those in the rest of the body empty themselves in like manner into the *vena cava*, which opens into the right auricle of the heart.

The nerves deduce their origin from the brain, or its appendages, in several pairs, of a cylindric form, (like so many skeins of thread with their respective sheaths,) which in their progress decrease by endless divisions and subdivisions, until at last they spread themselves into a texture of filaments so slender, and so closely interwoven with each other over the whole body, that the point of a needle can hardly be put upon any part of it, without touching the delicate branch of some nerve.

It has been found by many trials, that when an artery is laid bare, and a ligature made upon it, if it be opened with a lancet between the ligature and the heart, the blood will rush out with great violence; and a rapid, jerking stream will continue, (if it be not stopped by art,) until, through loss of blood, the animal faints or dies. But if the same artery be opened between the ligature and extremities, a few drops only will ooze out from the wounded coats. On the other hand, when a vein is laid bare, and a ligature made upon it, if it be opened between the ligature and the extremities, the blood will gush out, as we see in common venesection. But if the same vein be opened between the binding and the heart, no blood will appear. From these experiments it is obvious to the slightest attention, that the blood flows from the heart, through the arteries, to the extreme parts of the body; and returns again through the veins to the heart.

For the regular performance and continuation of this motion of the blood through all the different parts of the body, the heart, which is the *primum mobile*, giving the first impulse, is furnished with four distinct muscular cavities, that is, with an auricle and a ventricle on the right side, and an auricle and ventricle on the left. Through these cavities, curiously adapted to their respective offices, the blood circulates in the following order:—it is received from the veins, first into the right auricle, which, contracting itself, pushes the blood into the right ventricle, at that instant dilated. The moment this ventricle is filled, it contracts itself with great force, and impels the blood into the pulmonary artery, which, passing through the lungs, and returning by the pulmonary veins, is received into the left auricle of the heart, and from thence it is pushed into the left ventricle; which, being thus filled, contracts itself, and drives the blood with great rapidity to all the parts of the body, and from them it returns again through the veins into the right auricle of the heart, as before.

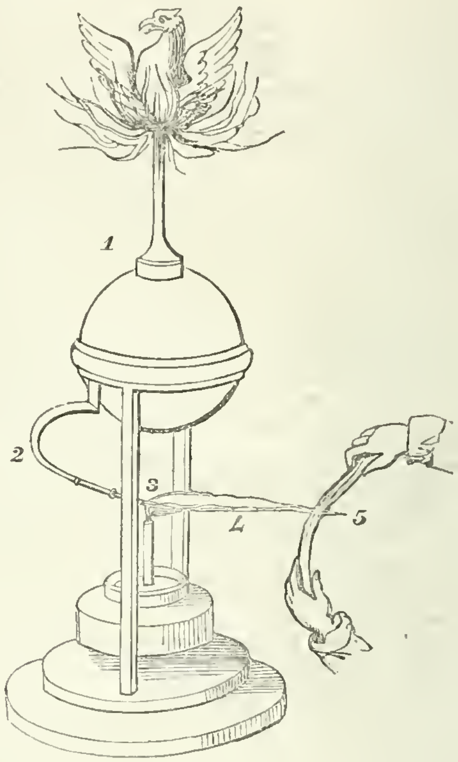
It is very remarkable, that we have here a double circulation: one from the right ventricle, through the lungs, to the left auricle of the heart, in order to convert the chyle into blood, and finally prepare it for the nourishment of the animal; the other, from the left ventricle, through the whole body, to the right auricle of the heart, which serves to apply that nourishment to every part, besides various other purposes.

But to proceed:—Of these four muscular cavities, the two auricles are contracted at the same instant, while the two ventricles are dilated; the ventricles, in their turn, are contracting themselves at the same instant that the auricles are dilating. The arteries, in like manner, beat in alternate time with the ventricles of the heart.

The nerves, as well as the veins and arteries, act their part in this rotation of the blood; for if the eighth pair of nerves which proceeds from the brain to the heart be bound up, the motion of the heart immediately languishes, and soon ceases entirely. Thus we have a species of perpetual motion, which none but a Being of infinite wisdom and power could produce; yet whose continuation requires the constant aid of the same hand that first gave it existence. The brain transmits animal spirits to the heart, to give it a vigorous contraction. The heart, at the same time, pushes the blood into the brain, to supply it with new spirits; by which means the head and the heart give continual mutual support to each other. But this is not all; the action of the heart sends the blood and other vital humours over the whole body by the arteries, and distributes nourishment and vigour to every part, (while perhaps the animal spirits, from the extremities of the nerves, return again into the blood,) and the whole refluent mass is conveyed back through the veins into the heart, which enables it, without intermission, to persist in rolling this tide of life.

But here it must not be supposed, that the arteries pass on to the extremities of the limbs, before they communicate with the returning veins; for upon this supposition, after an amputation has been performed, whatever blood might be brought to the stump by the arteries, it is certain, none of it could be carried back again to the heart; because the intercourse between the heart and the limbs would, in this case, be entirely cut off. But the all-wise Author of our being has provided for this exigency, by forming a great number of less branches from the larger arteries, which constantly communicate with corresponding branches of the returning veins. And hence, it is easy to conceive how the circulation is carried on after amputation has been performed.

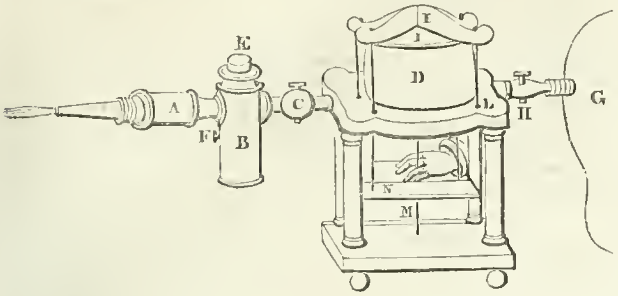
BLOWPIPE, Alcohol.—1. Copper ball, containing alcohol. 2. Tube to convey alcohol to, 3. A lamp, which keeps it boiling. 4. Jet of alcohol inflamed by the lamp. 5. Glass tube, bent by the flame.



This is really an useful instrument. The alcohol in the copper ball is boiled by the flame of the lamp placed underneath; this causes expansion, and the escape of the gas in a jet passing through the flame; and from its highly inflammable nature, a stream of intense heat is thus made to play upon any substance you wish to bring into fusion. There are many different kinds of blowpipes; but none more powerful than the Oxy-hydrogen blowpipe of Mr. Gurney.

A flux for the blowpipe, that will cause the particle of mineral, under examination, to run into a metallic globule upon the charcoal, as soon as any other now in use, may be thus made:—Take of borax 1 ounce, nitre 2 drachms, pounded flint glass 2 drachms, and calcined horse's hoof half an ounce; these are all to be fused together in a crucible, taking care to add the horse's hoof last, and stirring it well in with an iron spatula; when it is quite fluid, pour it into cold water, which will render it brittle, and thereby it may be easily pulverized. It is to be kept in well-closed phials, free from moisture, and the expense will be very trifling, compared with its great importance.

Hydrogen gas mixed with oxygen, furnishes an explosive compound of prodigious force. These gases, mixed in a bladder, in the exact proportion to form water, and afterwards condensed, and allowed to issue by a jet, which may be inflamed, and used in the operations of the blowpipe, under the title of Oxy-hydrogen Gas Blowpipe, of which the following figure represents Mr. Gurney's instrument.



Mr. Gurney has proved, by experiment, that the flame from a mixture of oxygen and hydrogen gases will pass through successive layers of the smallest wire gauze;—through the smallest apertures made in lead;—through plaster of Paris; pipe clay; the natural pores of cane; and those of Honduras mahogany. He has shewn, that no means have hitherto been adopted, capable of preventing the explosion of these mixed gases under certain circumstances; and has thus shewn the great danger attending the use of instruments. One of the principal advantages attending the well constructed blowpipe before us, consists, it is said, in its being *perfectly safe;* and every apprehension of danger being thus removed from the mind of the operator, he is enabled to give his undivided attention to the changes and effects taking place in the substance operated upon; and whilst coolly examining, and noting every circumstance, a slight pressure with one hand is all that is requisite to produce a degree of heat of any required intensity. In this machine, A is the safety chamber, B a water trough, through which the gas is made to pass from the gasometer D, by the stop-cock C, through a tube which reaches to the bottom of the water trough; E is a cork, fitted into the neck of the same, from which it is thrown out, should an explosion take place on the surface of the water; F is a gauge, to indicate the necessary height of the column of water in the trough; G is a transferring bladder, which is made to screw and unscrew to and from the stop-cock H, and for supplying the gasometer with the gases, which may be charged and recharged at pleasure by an assistant during its action, so as to keep up the most intense flame, for any length of time. A valve is placed between the gasometer and the transferring bladder, which prevents the return of the gas; I, I is the light wooden, or stiff pasteboard cap, which combines sufficient strength, with great lightness, so that in case an explosion of the gasometer should happen, it is merely thrown a short height into the air, by the force rupturing the strings which connect the cap to the press board. To these strings are attached small wires, which pass through the table of the instrument, as at L into the press board below, where they are secured; this press board is kept in an horizontal position by the stand, so that when the requisite pressure is given to it, the cap I, I is brought to bear equally on the gasometer D. The gasometer bladder, (or silk bag,) is tied to a piece of bladder, which screws into a long tube, laid into and across the table, which permits it to be unscrewed at pleasure from the body of the instrument, and immersed in warm water, when it requires softening; affording also the means of fixing on another bladder, if any accident renders it necessary. The stop-cock of the charging bladder G is fixed at one end of the tube just described, and the stop-cock of the water trough on the other.

To operate with the instrument, pressure by the hand is applied to the press board, which draws down the cap I, I on the gasometer D, and forces the gas which it contains through the stop-cock C, through the water tube and safety chamber A, to the jet at the end, where it is burned. When the pressure on the press board is too slight, or when the hand is taken off, the flame returns into the safety chamber, and is extinguished. When it is required to suspend the operation, the hand need only be taken off from the pressing board, the water in the trough acts as a self-acting valve, in preventing the escape of the gas from the instrument, and saves the necessity of turning the stop-cock. A silk tube is attached to the end of the tube before described in the water trough, which prevents the splashing of the water, sometimes occasioned by unskilful management.

The ease and confidence with which this instrument may be used, and its wonderful power in reducing, almost instantaneously, the hardest and most refractory substances, will enable the chemist, the philosopher, and the artisan, to avail themselves of the astonishing powers of an oxy-hydrogen blowpipe, not only without any personal risk, but even without the apprehension of any. Gun flints are instantly fused by this instrument, and formed into a transparent glass; (but owing to the rapid expansion of the water of crystallization, which causes the flints to break and fly off in pieces, it is recommended that they be first deprived of it by calcination.) China melts into a perfect crystal. All kinds of porcelain are readily fused; previously assuming a beautiful white vitrified appearance. Rock crystal is quickly melted, giving out a beautiful light. Emerald, sapphire, topaz, beryl, and all the other precious stones, melt before it into transparent glassy substances. Barytes, strontia, lime, allumina, exhibit very striking and beautiful phenomena. Magnesia fuses into hard granular particles, that will scratch glass. The metals (even platina) are *all* quickly fused by it. A steel file, brought into contact with the flame, fuses and scintillates in the most beautiful manner, forming a magnificent firework. In a word, all descriptions of stones, slates, and minerals, are melted, sublimed, or volatilized, by its all-subduing power.

BLOWING *of Glass. See* GLASS.

BLOWING *Machines. See* FURNACE.

BLUE, one of the seven primitive colours of the rays of light, into which they are divided when refracted through a glass prism. *See* COLOURS and PRISM. The blue colour of the sky is a remarkable phenomenon, which has been variously accounted for by different philosophers. La Hire, after Leonardo de Vinci, attributed it to the effect which is produced by viewing a dark body through a white transparent one, which he observes always gives the sensation of blueness; and thus the sky being itself totally devoid of light, when viewed through the air illuminated and whitened by the sun, appears of that blue colour so constantly observed. According to Newton, however, the phenomenon is to be accounted for on other principles. He observes, that all the vapours, when they begin to condense and coalesce into natural particles, become first of such a bigness as to reflect the azure rays, before they can constitute clouds of other colours. Bouguer ascribes this blueness of the sky to the constitution of the air itself, being of such a nature that the fainter coloured rays are incapable of making their way through any very considerable portion of it. We conceive, that this blue colour is occasioned by the vapours mixed with air, and which have the property of reflecting the blue rays more copiously than any others.

BOATS, small open vessels, conducted on the water by rowing or sailing, are distinguished by different names, according to their size and construction. The long boat, usually the largest boat that accompanies a ship, is generally furnished with a mast and sails, and may be armed and equipped for cruising short distances; her principal employ, however, is, to bring heavy stores or provisions on board, and also to go up small rivers to fetch water, wood, &c. The launch, a boat which has greatly superseded the use of the long boat, particularly by merchant ships in the Mediterranean, is longer, more flat-bottomed, and by rowing a greater number of oars, is better adapted for going into narrow and shallow rivers. The barge, a long, narrow, and light boat, employed to carry the principal officers, as admirals and captains of ships of war, and is very unfit for sea. A pinnace resembles a barge, but is smaller, never rowing more than eight oars, whereas a barge never rows less than ten; the pinnace is for the accommodation of the lieutenants, &c. The cutters of a ship are broader, deeper, and shorter than the barge or pinnace, are fitter for sailing, and commonly employed in carrying light stores, passengers, &c. to and from the ships; they are built differently from the former boats; the lower edge of every plank overlaying the upper edge of the plank below it, which is called clinch work. They generally row six oars; sometimes only four, which last is termed a jolly boat. Yawls resemble pinnaces, but are generally rowed with six oars. A wherry is a sharp light boat, used in rivers or harbours. The wherries allowed to ply about London, are either scullers wrought by a single person with two oars, or oars wrought by two persons, with each an oar. A Moses is a flat-bottomed boat used in the West Indies, for bringing off hogsheads of sugar, and is termed single or double, according to its size. A punt is a sort of oblong flat-bottomed boat, nearly resembling a floating stage. A felucca is a large and strong passage-boat, used in the Mediterranean, having from ten to sixteen banks of oars.

BOAT-HOOK, an iron hook with a sharp point on the hinder part thereof; it is fixed upon a long pole, by the help of which a boat is either pulled to, or pushed off from, any place.

BOB of a *Pendulum*, or Ball of a *Pendulum*, is the metallic weight which is attached to the lower extremity of a pendulum rod, by means of a tapped adjusting nut, at such a distance from the point of suspension as the time of a given vibration requires. *See* Pendulum.

BODY, or Solid, in Geometry, is that which has three dimensions, *viz.* length, breadth, and thickness.

Body, in Physics of Natural Philosophy, is a solid, extended, palpable substance; of itself merely passive, and indifferent either to motion or rest; but capable of any sort of motion, and all figures and forms. Body is composed, according to the Peripatetics, of *matter, form,* and *privation;* according to the Epicureans and Corpuscularians, of an assemblage of hooked heavy *atoms;* according to the Cartesians, of a certain quantity of *extension;* and according to the Newtonians, of a system of association of solid, massy, hard, impenetrable, moveable *particles*, ranged or disposed in different manners, whence result bodies of different forms, which receive particular denominations, according to the circumstances under which they appear. These elementary or component particles of bodies must be infinitely hard, so as ever to remain unbroken and unchanged; which, as Newton observes, is necessary, in order to the world's remaining in the same state, and bodies continuing of the same nature and texture in several ages.

Bodies are either *hard, soft,* or *elastic.* A *hard Body* is that whose parts do not yield to any stroke or percussion, but retains its figure unaltered. A *soft Body* is that whose parts yield to any stroke or impression, without restoring themselves again. An *elastic Body* is that whose parts yield to any stroke, but immediately restore themselves again, and the body retains the same figure as at first. We know not, however, of any bodies that are perfectly hard, soft, or elastic; but all possess these properties in a greater or less degree.

Bodies are also either *solid* or *fluid.* A *solid Body* is that in which the attractive power of the particles of which it is composed exceed their repulsive power, and, consequently, they are not readily moved one among another, and therefore the body will retain any figure that is given to it. A *fluid Body* is that in which the attractive and repulsive powers of the particles are in exact equilibrio, and therefore yields to the slightest impression. *See* Solid and Fluid.

Regular Bodies, or *Platonic* Bodies, are those which have all their sides, angles, and planes, similar and equal, of which there are only the five following, *viz.*

1. Tetraedron, contained under 4 equilateral triangles.
2. Hexaedron, ... 6 squares.
3. Octaedron, ... 8 triangles.
4. Dodecaedron, ... 12 pentagons.
5. Icosaedron, ... 20 triangles.

For the method of forming the five regular bodies, as also for finding out the surfaces and solidities, see the respective articles.

BOILING. *See* Ebullition.

BOMB, a large shell of cast iron, having a great vent to receive the fusee, which is made of wood. Bombs are of different magnitudes, and are filled with gunpowder and other combustibles. When shot from the mortar, the fusee in them takes fire, and its length is so adjusted, that by the time the shell has finished its flight, the fusee has burnt up, and explodes the gunpowder within so as to burst the shell to pieces just as it is falling to the ground; this, of course, increases its execution, and causes greater devastation. A grenade resembles a bomb, but is less, and may be cast with the hand. The usual weight of a grenade is three pounds; and filled with a strong powder lighted by a fusee.

BOOKBINDING. The leaves being accurately folded, are beaten with a hammer on a stone, to make them smooth, and lie close; they are then put into a press, and sewed on boards, after which the backs are glued, and the bands opened and scraped to fix the pasteboard covers; the back is rounded with a hammer, and the book is fixed in a press, between two boards. Holes are then made for fixing the pasteboards to the volume, which is pressed a third time. It is then put to the cutting-press, between two boards, one lying even with the press for the knife to run upon, the other above for the knife to run against; after this operation, the pasteboards are squared; the leaves sprinkled, by dipping a brush in vermilion and sap green, holding it in one hand, and spreading the hair with the other. The leather covers are moistened, cut to the size of the book, smeared with paste, and afterwards stretched over the pasteboard on the outside, and doubled within, after having taken off the four angles, and indented and platted the cover at the head-band. The book is now covered and bound between two bands, and set to dry. It is afterwards washed with paste and water, and then sprinkled with a brush; if marbling be required on the leathern covers, the spots are made by the addition of vitriol. The book is glazed with the white of an egg, and polished with a hot iron; the letters and ornaments are made with gilding tools, or brass cylinders, rolled along by a handle. To apply the gold, the leather is glazed with whites of eggs diluted with water, when nearly dry the gold leaf is laid on, and the letters, or ornaments, are made with tools heated in a charcoal fire. For preserving books from the depredations of worms,—mineral salts, alum, and vitriol should be mixed with the paste used by bookbinders; and instead of flower, the paste should be made of starch. A little pulverized alum is useful, if strewed between the book and its cover, and upon the shelves of the library. A few drops of any perfumed oil will secure libraries from the consuming effects of mouldiness and damp. Russian leather, which is perfumed with the tar of the birch-tree, never moulders; and merchants suffer large bales of this article to lie in the London docks in the most careless manner, knowing that it cannot sustain any injury from damp.

BOOM, in Marine Fortification, a strong iron chain, fastened to a number of spars, and extending athwart the mouth of a harbour or river, to prevent the enemy's vessels from entering, but may be occasionally sunk or removed.

Boom, a long pole run out from different places in the ship, to extend the bottoms of particular sails, as jib-boom, flying jib-boom, studding-sail booms, driver or spanker-boom, ring-tail boom, main-boom, square-sail boom, &c.

Fire Booms, strong poles occasionally thrust out from a ship's side, &c. to prevent the approach of fireships, firestages, or vessels accidentally on fire.

Booming, among Sailors, denotes the application of a boom to the sails. Booming of the sails is never used but in quarter winds, or before a wind. When a ship is said to come booming towards us, it signifies that she comes with all the sail she can make.

BOOTES and Mons Menalus, a Constellation in the northern hemisphere. Grecian fable makes Böotes to be Arcas, a son of Jupiter and Calisto. Juno, who was jealous of Jupiter, changed Calisto into a bear; and she was near being killed by her son Arcas in hunting. Jupiter, to prevent further mischief from huntsmen, made Calisto the constellation Ursa Major, and on the death of Arcas, transferred him to heaven, with the title and office of Bear Guard. The splendid star Arcturus, is frequently mentioned in holy writ, particularly in the book of Job. This star is placed near Virgo, in a line with Spica, on the meridian of the Ecliptic. The ancient Greeks called this constellation Lycaon. The Hebrews call it "the Barking Dog." The Latins, among other names, called Böotes *Canis.* Going back to the time when Taurus opened the year, and when Virgo was the fifth of the zodiacal signs, we shall find the brilliant star Arcturus, so remarkable for its red and fiery appearance, corresponding with a period of the year as remarkable for its heat. Pythagoras, who introduced the true system of the universe into Greece, received it from Oenuphis, a priest of On, in Egypt. And this college of the priesthood was the noblest of the East, in cultivating the studies of philosophy and astronomy. Among the high honours which Pharaoh conferred on Joseph, he very wisely gave him in marriage "a daughter of the priest of On." Joseph is said to have died 1635 years before Christ. The supposed era of the history of the book of Job is fixed 1513 years before Christ. These facts are 900 years prior to the age of Pythagoras. And it is 4000 years since the bull ceased to be the leader of the celestial host. The Greeks cannot then claim the invention of the constellation Böotes.

Boundaries and Contents of this Constellation:—North by Draco, east by Corona Borealis and Serpens, south by Virgo, and west by Canes Venatici and Coma Bernices. Böotes contains 54 stars, namely, one of the 1st magnitude, six of the 3d, eleven of the 4th, &c. Arcturus, the largest star in this constellation, having 211° 54′ 16″ right ascension, and 20° 8′ 0″ N. declination, rises and culminates, at London, as in the following table: Meridian Altitude, 58° 37′.

MONTH.	RISES.	CULM.	MONTH.	RISES.	CULM.
	ho. mi.	ho. mi.		ho. mi.	ho. mi.
Jan.	11 30 A.	7 15 M.	July	11 26 M.	7 35 A.
Feb.	9 16 A.	5 5 M.	Aug.	9 22 M.	5 30 A.
Mar.	7 30 A.	3 15 M.	Sept.	7 18 M.	3 33 A.
April	5 35 A.	1 26 M.	Oct.	5 18 M.	1 41 A.
May	3 45 A.	11 35 A.	Nov.	3 15 M.	1 45 M.
June	1 35 A	9 30 A.	Dec.	1 14 M.	9 30 M.

Arcturus rises on the north-east by east point of the compass; and from the circumstance of its variation being greater, in consequence of a proper motion of its own, it is supposed to be the nearest star to the earth of any in the northern hemisphere.

BOOT-TOPPING, the operation of scraping off the grass, slime, shells, &c. which adhere to the bottom of a ship, near the surface of the water, and daubing it over with a mixture of tallow, sulphur, and rosin. Boot-topping is chiefly performed where there is no dock.

BORAX, in Chemistry, a salt in appearance somewhat like crystals of alum, brought originally from the East Indies in an impure state, and afterwards freed from its impurities by certain processes in the European countries. It was long a matter of uncertainty, whether this salt be a natural or factitious substance in those countries from whence it is brought; but it is now beyond a doubt, that it is naturally produced in the mountains of Thibet, from whence other parts of the eastern continent are supplied. It is produced in the kingdom of Jumlate, about thirty days' journey north from Betowle, a small principality about 200 miles north-east of Lucknow. The place where it is found is said to be a small valley surrounded with snowy mountains, in which is a lake about six miles in circumference; the water of which is constantly so hot that the hand cannot bear it for any time. Around this lake the ground is perfectly barren, not producing even a blade of grass; and the earth is so full of a saline matter, that after falls of rain or snow it concretes in white flakes on the surface, like the natron of Hindostan. On the banks of this lake, in the winter season, when the falls of snow begin, the earth is formed into small reservoirs six inches high; when these are filled with snow, the hot water from the lake is thrown upon it; which, together with the water from the melted snow, remains in the reservoir, to be partly absorbed by the earth, and partly evaporated by the sun; after which, there remains at the bottom a cake of sometimes half an inch thick of crude borax, which is taken up and reserved for use. It can only be made in the winter season, because the falls of snow are indispensably requisite, and also because the saline appearances upon the earth are strongest at that time. When once it has been made on any spot, it cannot be made again on the same spot till the snow has fallen and dissolved three or four times, when the saline efflorescence appears as before.

BORING, in a general sense, the art of perforating, or making a hole through any solid body. Boring of waterpipes is as follows:—The poles of alder, which is a very useful wood in making pumps, waterpipes, &c. being laid on horses or trestles of a foot height, to rest the auger upon while they are boring, they set up a lathe to turn the least end of the poles, to fit them to the cavities of the great end of the others. They turn the small ends of the poles about five or six inches in length, to the size they intend to bore the bigger ends about the same depth, *viz.* five or six inches. This is designed to make a joint to shut each pair of poles together, the concave part being the female part, and the other the male of the joint. In turning the male part, they turn the channel in it, or a small groove at a certain distance from the end, and in the female part they bore a small hole to fit over this channel. This being done, they bore the poles through; and to prevent them from boring out at the side, they stick great nails at each end to be a guide in boring. It is usual, however, to bore them at both ends; so that a crooked pole can be bored through and not spoil it.

BORING, in Farriery, a cruel and absurd method of treating a wrenched shoulder.

BORING, in Mineralogy, a method of piercing the earth with scooping irons, which being drawn back at proper times, bring up with them samples of the different strata through which they have passed; by the examination of which, the skilful mineralogist will be able to guess whereabouts a vein of ore, or a stratum of coal, may lie; or whether it will be worth while to open a mine for the purpose of working it.

BOSCOVICH, ROGER JOSEPH, a very eminent mathematician and philosopher, was born May 11, 1711, at Ragusa. He studied Latin grammar in the schools which were taught by the Jesuits, in his native city, until 1725, when, in consistence with a maxim of the Jesuits, to send their most eminent pupils to Rome for the completion of their education, he was removed to that city. After this he soon acquired very great reputation for his eminent attainments in divinity and science: at three successive periods he became professor of mathematics and astronomy at Rome, at Pavia, and at Milan. When the order of Jesuits was suppressed, he was invited to Paris, and received the place of director of the optical instruments of the marine. Previous to this, however, he had been employed, in conjunction with father Maire, in measuring a degree of the meridian in Italy, and in correcting the maps of the papal state. He published in 1755, an interesting account of the expedition in which these objects were effected. He had also been employed in adjusting a disagreeable affair between the republic of Lucca and the regency of Tuscany; and in a similar business between the republic of Ragusa and the court of Great Britain; which brought him to London, where he soon became acquainted with the most celebrated British philosophers. He remained at Paris ten years, but being a foreigner, his celebrity was envied; this, together with the irreligion which then prevailed among the French philosophers, was disagreeable to him, so that he obtained leave for two years' absence to revisit his friends in Italy. He tarried at Bassano, where he printed five volumes in large octavo, containing a real treasure of optical and astronomical knowledge. From Bassano he went to Rome, and thence to Milan, where he took up his abode, being in the neighbourhood of his favourite observatory at Brera. Here he continued to enjoy the pleasures of study; and, occasionally, the society of many respected friends, until his two years of absence were nearly expired: his unwillingness to leave Italy, and at the same time a solicitude to avoid the charge of ingratitude from the French nation, occasioned great perplexity of mind, which was followed by deep melancholy, a disordered imagination, and, at length, direct insanity. He had, indeed, some lucid intervals, and once there were hopes of a recovery; but he soon relapsed, and an imposthume breaking in his breast, put an end to his mortal existence in February, 1787, in his 76th year.

BOSSAGE, in Architecture, a term used for any stone that has a projecture, and is laid rough in a building, to be afterwards carved into mouldings, capitals, coats of arms, &c. Bossage is also that which is otherwise called rustic work; and consists of stones which advance beyond the naked or level of the building, by reason of indentures or channels left in the joinings. These are chiefly used in the corners of edifices, and thence called rustic quoins. The cavities or indentures are sometimes round, sometimes chain-framed, or bevelled, sometimes in a diamond form, sometimes enclosed with a cavetto, and sometimes with a listel.

BOTANY. The history of the vegetable kingdom, or, as it is termed, *Botany*, is a science which includes the practical discrimination, the methodical arrangement, and the systematic nomenclature. of vegetables. Vegetables are organized productions, supported by air and food, endowed with life, and subject to death, like animals. They have, in some instances, *spontaneous*, not voluntary motion. They are sensible to the supply of nourishment, the action of the air and light, and thrive or languish according to the wholesome application of these stimulants. This is evident to all who have ever seen a plant growing in a situation for which it is not suitable. Those who have gathered a rose, know how soon it withers; and the familiar application of its fate to that of human life and beauty, is not more striking to the imagination, than philosophically correct.

The external covering of plants is commonly transparent and smooth; but sometimes it is downy; and sometimes so hard, that flint has been detected in its composition. The Dutch rush serves as a file to polish wood, ivory, and even brass. Under the cuticle, is found the *cellular integument* of a pulpy texture, and the seat of colour. It is usually green in the leaves and stems, and is dependent for its hue on the action of light. When the cellular integument is removed, the bark presents itself; in plants and branches only one year old, the bark consists of a simple layer. In the branches and stems of trees, it consists of as many layers as they are years old. The Peruvian bark affords ' a cooling draught to the fevered lip;' that of the cinnamon yields a rich cordial; that which is stripped from the oak, is used for tanning. Immediately under the bark is situated the wood, which forms the great bulk of trees and shrubs. This also consists of numerous layers, as may be observed in the fir, and other trees; and from these concentric circles, the age of the tree is determined. Within the centre of the wood is the *medulla* or pith, a cellular substance, juicy when young, extending from the roots to the summits of the branches. In some plants, as in grasses, it is hollow, merely lining the stem. The trunk enlarges by the formation of the new *liber*, or inner bark, every year, the undermost layer is transformed into *cortex*, or outer bark, becoming the *laburnam*, or soft wood of the next, and the laburnam becoming the *lignum*, or hard wood.

The chemical or elementary principles of vegetables, are, carbon, water, and air; or hydrogen 15 parts, and oxygen 85 parts, for the constituent parts of 100, water; and azote and nitrogen 72, and oxygen 28, as the constituent parts of 100, atmospheric air, and carbon.

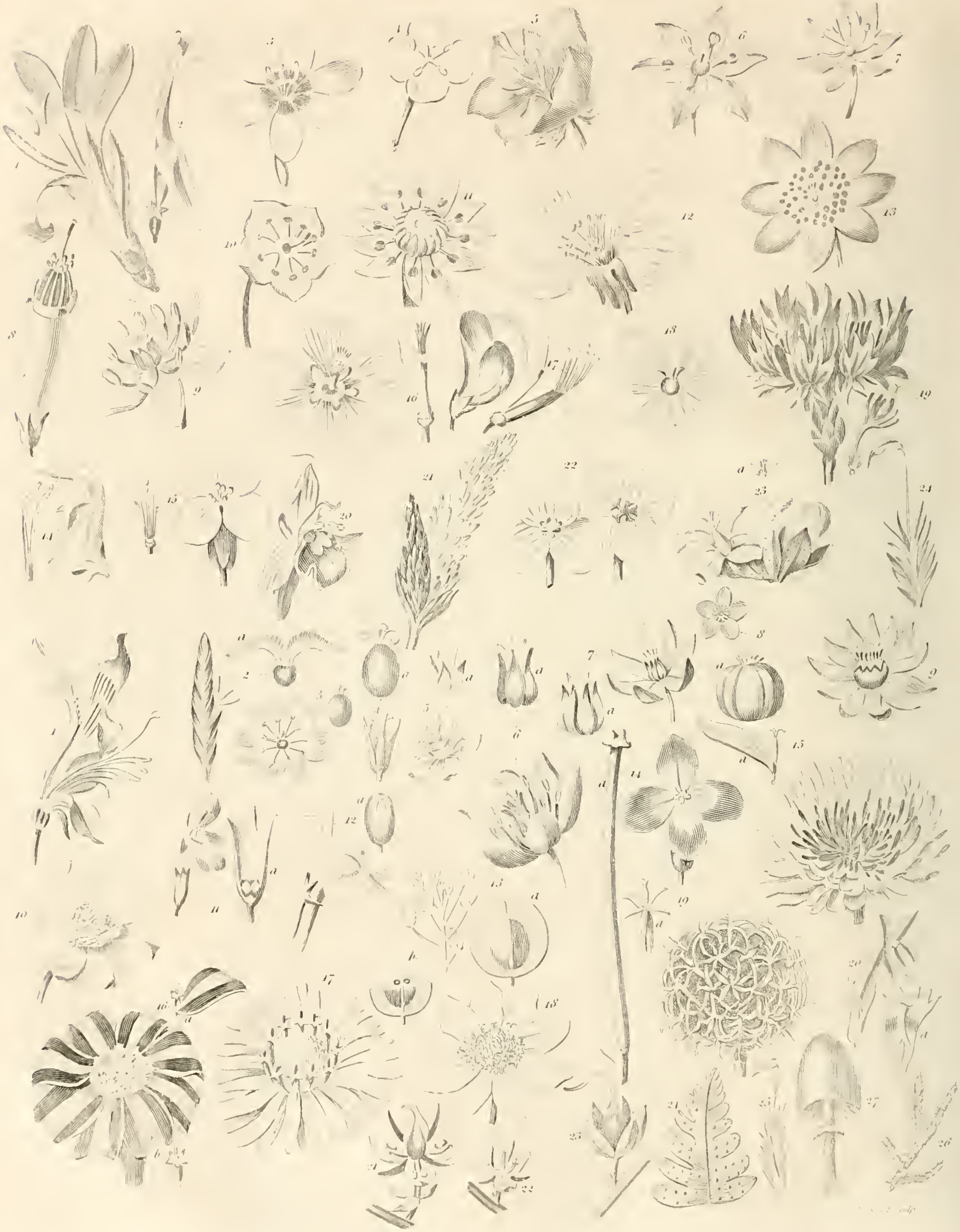
Vegetables generate or give out oxygen or vital air, in the light or sunshine, by a natural process of their own. The saccharine and oily productions of vegetables are parts of their sap or juices; but the turpentine, bitter, and acid principles, are effects of secretion. The green colour of vegetables arises from the oil they contain; the rays of the sun extract the oxygen from the outer surface, and leave the carbon and hydrogen the constituent parts of oil. Healthy vegetables, in general, perspire water by the under part of their leaves, equal to one-third of their weight, every twenty-four hours. Nor do they derive their substance in a principal degree from the matter of the soil in which they grow; but they are created as it were by a vital principle of their own, out of air and water, and of the imperceptible matters combined with air and water, from which they derive distinctions of smell, taste, and substance.

The general constituent principles of vegetables, *viz.* hydrogen, carbon, oxygen, &c. do not exist in them in a simple and uncombined state, but joined in various proportions, forming compound substances, that make up the whole vegetable; and the following are the principal substances met with in vegetables:—1 Mucilage. 2. Fixed and volatile oils. 3. Resin. 4. Gum resins. 5. Caoutchouc. 6. Camphor. 7. Wax. 8. Honey. 9. Sugar. 10. Gluten. 11. Fecula. 12. Tannin. 13. Woody fibre. 14. Colouring matter. 15. Acids. 16. Miscellaneous substances.—17. Amber, and 18. Asphaltum, are also supposed to be of vegetable origin.

Mucilage. Various parts of vegetables impart to water, if boiled with them, a certain viscous matter, causing consistency. This is called mucilage. Some trees suffer their mucilage to transude, some spontaneously, or by incisions made in them. When it has become concrete by drying in the air, it is called gum. In this way gum arabic, gum senegal, and cherry-tree gum, are formed. Mucilage is without taste; soluble in water, but not in oils or alcohol. It is not changed by exposure to the air. From the experiments of Cruikshank, it appears to consist of oxygen, hydrogen, nitrogen, carbon, and lime.—*Fixed and Volatile Oils.* Oil is composed of carbon and hydrogen, with a small portion of oxygen. Oils are divided into fat or fixed oils, and volatile or essential oils. Fixed oil is usually obtained by expression, chiefly from the seed and kernels of plants. Volatile oil is procured by distilling aromatic plants with water.—*Resins* exist in the vessels of certain trees, and frequently exude from them spontaneously. Sometimes they are procured by making incisions in the trees, and sometimes by distilling the wood. They are considered as volatile oils combined with oxygen. They are soluble in alcohol and oils, but not in water. It is this property that renders them so valuable as varnishes. They are very inflammable, and melt with a slight heat. The principal resins are the turpentine, the guaiacum, mastic, copal, and sandarac.—*Gum resins* appear to be a natural mixture of resin and mucilage. They are partly soluble in water, and partly in alcohol. Gum ammoniac, assafœtida, and opium, are gum resins.—*Caoutchouc*, elastic gum, or Indian rubber, resembles a resinous gum. It is elastic, inflammable, and insoluble in water or fat oils. It is partly soluble in volatile oils, and entirely so in nitric ether. It is the juice of a tree of the euphorbia tribe. When first exuded, it is of a milky consistence and colour, but it gradually thickens, and is blackened by smoke, as it flows round the clay balls on which the bottles are made. It is cut easily, if the knife be dipped in water.—*Camphor*, a volatile oil, is extracted from a species of laurel which grows in China, and the East Indies. It is very inflammable, and sublimes by a gentle heat. It is soluble in ether, alcohol, the oils, and acetic acid. It is highly odorous, and prevents the spreading of contagious disorders.—*Wax*, a vegetable substance, found in the greatest quantity on the anthers of flowers, and collected by bees, is insoluble in water and alcohol, but soluble in volatile and fixed oils. It is very inflammable. Its components are the same as those of volatile oils.—*Honey* is formed chiefly in the pistils or female organs of flowers, whence it is collected by the bees: it appears to be sugar dissolved in mucilage.—*Sugar* is produced in the greatest quantity from the sugar cane; but it may also be obtained from the sugar maple, the beet-root, carrot, &c. Its constituents are oxygen, carbon, and hydrogen.—*Gluten*, an elastic viscid substance, is found in vegetables, and chiefly in wheat flour; it is soluble in water, and very slightly so in alcohol.—*Fecula*, or *Starch*, forms the principal part of the substance which is washed away in order to obtain the gluten from the grain. When the fluid is suffered to stand, a white powder subsides, which is the starch. It is also obtained from potatoes.—*Tannin* matter is found in the gall nut, the bark of oak trees, and other astringent parts of vegetables.—*Woody fibre*, constituting the basis of wood, may be separated from every other substance, by boiling wood shavings in water to dissolve the extractive matter, and then in alcohol to separate the resins, &c.—*Colouring matter* is found in vegetables combined with, 1, the extractive principle; 2, with resins; 3, with fecula; 4, with gum.—*Acids*, existing ready formed in vegetables, are the citric, malic, oxalic, gallic, benzoic, tartaric, acetous, suberic. Besides which, we find various other substances in vegetables, as sulphur, iron, manganese, lime, alumine, magnesia, barytes, &c.

Roots are necessary to fix and hold plants in the earth, from which they imbibe nourishment. Roots are either annual, or living for one season, as in barley; biennial, which survive one winter, and, after perfecting their seed, perish at the end of the following summer, as wheat; or perennial, which remain and produce blossoms for an indefinite number of years, as those of trees and shrubs in general. The root consists of two parts: the *caudex* or stump, which is the body or knot of the root, from which the trunk and branches ascend, and the fibrous roots

BOTANY. *The Classes, or Primary Divisions of the Sexual System.*



The Orders, or Secondary Divisions of the Sexual System.

branching from the *caudex*.—Buds are, in most instances, guarded by scales, and furnished with gum or woolliness, as an additional defence. Buds are various in their forms, but very uniform in the same species, or even genus. They unfold the embryo plant.—The trunk of a tree includes the stems or stalks. The stem, as it advances in growth, either supports itself, or twines round other bodies. It is either simple, as in the lily; or branched, as in other plants.—Leaves are generally so formed as to present a large surface to the atmosphere. When of any other hue than green, they are said to be coloured. The internal surface of a leaf is vascular and pulpy, clothed with a cuticle, very various in different plants, but its pores are always so constructed, as to admit of the requisite evaporation or absorption of moisture, as well as to admit and give out air, and light also acts through this cuticle.

The effect of moisture must have been observed by every one. By absorption from the atmosphere, the leaves are refreshed; by evaporation, when separated from their stalks, they soon fade and wither. The nutritious juices, imbibed from the earth, become sap, and are carried by appropriate vessels into the substance of the leaves, and these juices are returned from each leaf into the bark. This is effected by a double set of vessels, analogous to the arteries and veins in animals, and is the circulation of the vegetable blood or sap. The sap is carried into the leaves for the purpose of being acted upon by air and light, with the assistance of heat and moisture, and by all these agents, a most material change is wrought in the component parts of the sap, according to the nature of the secretions. The green colour of the leaves is owing to the action of light, but they are subject to a disease by which they become partially spotted or streaked, and in this state are variegated. The irritable nature of leaves is very extraordinary, for the sensitive plant, common in hot-houses, when touched by any extraneous body, folds up its leaves one after another, and the footstalks droop, as if dying.

Props, or falcra, are appendages to the true leaves, or to their stalks. Inflorescence, treats of the different kinds or modes of flowering. Sometimes the flowers surround the stem in a garland or ring, as in mint, deadnettle, &c. In other plants, a cluster, which bears several flowers, each on its own stalk, like a bunch of currants. In other plants, numerous crowded flowers are ranged along an upright, common stalk, expanding progressively, as in wheat and barley. Again, we find a flat-topped spike, as in the cabbage and wallflower.

Fructification is a term comprehending not only the parts of the fruit, but those of the flower. The parts of fructification are described by many technical words, but include chiefly the flowercup, or external covering of the flower; the calix, consisting in general of the coloured leaves of the flower; the stamens, and the cells containing the pollen or fecundating dust: the pistils stand in the centre of the circles formed by the stamens, and consist of the germen or rudiments of the future fruit or seed; the seed are composed of the embryo or germ, and are often accompanied by accessory parts; as spines, hooks, scales, and crests, generally serving to attach such seeds as are furnished with them, to the rough coats of animals, and thus promote their dispersion.

Classification, though last in order, is first in importance; and of all the systems of botany, that of Linnæus, now generally acknowledged and adopted, is founded on the number, situation, and proportion of the stamens and pistils, whose uses and structure have been just explained. The following twenty-four Classes owe their distinctions principally to the stamens.

THE CLASSES; *or, Primary Divisions of the Sexual System.*
(See the Plate.)

Fig. 1. MONANDRIA, flowers with one stamen.—2. DIANDRIA, flowers with two stamens.—3. TRIANDRIA, flowers with three stamens.—4. TETRANDRIA, flowers with four stamens, all of the same length.—5. PENTANDRIA, flowers with five stamens.—6. HEXANDRIA, flowers with six stamens, all of the same length.—7. HEPTANDRIA, flowers with seven stamens.—8. OCTANDRIA, flowers with eight stamens.—9. ENNEANDRIA, flowers with nine stamens.—10. DECANDRIA, flowers with ten stamens.—11. DODECANDRIA, flowers with twelve stamens.—12. ICOSANDRIA, flowers with about twenty stamens, attached to the calix, or sometimes, in part, to the corolla.—13. POLYANDRIA, flowers most commonly with more than twenty stamens, attached to the receptacle.—14. DIDYNAMIA, flowers with two longer stamens.—15. TETRADYNAMIA, flowers with four longer stamens.—16. MONADELPHIA, filaments united into one brotherhood.—17. DIADELPHIA, filaments forming two brotherhoods.—18. POLYADELPHIA, filaments forming more than two brotherhoods.—19. SYNGENESIA, anthers united, composing a hollow cylinder, through which the style passes.—20, GYNANDRIA, stamens on the pistil.—21. MONŒCIA, staminiferous and pistiliferous flowers on the same plant.—22. DIŒCIA, staminiferous and pistiliferous flowers on different plants.—23. POLYGAMIA, different dispositions on the same plant.—24. CRYPTOGAMIA, flowers inconspicuous.

THE ORDERS; *or, Secondary Divisions of the Sexual System.*

Fig. 1. *Monogynia*, containing hermaphrodite flowers with one pistil, or female organ.—2. *Digynia*, hermaphrodite flowers with two pistils; *a*, the pistils detached from the flower.—3. *Trigynia*, hermaphrodite flowers with two pistils; *a*, the pistils separated from the flower.—4. *Tetragynia*, hermaphrodite flowers with four pistils; *a*, the pistils separated from the flower.—5. *Pentagynia*, hermaphrodite flowers with five pistils; *a*, the pistils separated from the flower.—6. *Hexagynia*, hermaphrodite flowers with six pistils; *a*, the pistils separated from the flower.—7. *Heptagynia*, hermaphrodite flowers with seven pistils; *a*, the pistils detached from the flower.—8. *Decagynia*, hermaphrodite flowers with ten pistils; *a*, the pistils separated from the flower.—9. *Dodecagynia*, hermaphrodite flowers with twelve pistils, or female organs.—10. *Polygynia*, hermaphrodite flowers containing an indefinite number of pistils, or female organs.—11. *Gymnospermia*, the name of the first order in the class DIDYNAMIA; in which *a* represents a longitudinal section of the flower, to display the four naked seeds in the bottom of the calix.—12. *Angiospermia*, the name of the second order in the class DIDYNAMIA, containing such hermaphrodite flowers with four stamens, two longer than the others, as have their seeds contained in a vessel; *a*, the pericarp, or vessel, detached from the flower.—13. *Siliculosa*, the first order in the class TETRADYNAMIA, containing such flowers possessed of the classical character, as have their seeds contained in a short round pod; *a*, the *silicula*, or pod, divided, to shew the seeds separated from the flower.—14. *Siliquosa*, the second order in the class TETRADYNAMIA, containing such flowers possessed of the classical character, as have their seeds contained in a *siliqua*, or long slender pod, to each suture of which they are alternately attached; *a*, the *siliqua* detached.—15. *Polygamia Æqualis*, the first order in the class SYNGENESIA; *a*, a floret separated from the aggregate.—16. *Polygamia Superflua*, the second order in the class SYNGENESIA; *a*, represents a female floret in the circumference or ray; *b*, an hermaphrodite floret in the centre or disk.—17. *Polygamia Frustranea*, the third order in the class SYNGENESIA.—18. *Polygamia Necessaria*, the fourth order in the class SYNGENESIA.—19. *Polygamia Segregata*, the fifth order in the class SYNGENESIA; *a*, a floret with its proper flower-cup detached from the aggregate.—20. *Monogamia*, the sixth order in the class SYNGENESIA; *a*, representing a section of the flower, to exhibit the union of the stamens by the anthers.—21, 22, 23. *Triœcia*, the third order in the class POLYGAMIA, in which hermaphrodite flowers are intermingled with male or female flowers, or both, on one, two, or three plants.—24. *Filices*, Ferns, the first order; 25. *Musci*, Mosses, the second order; 26. *Algæ*, Sea-weed, &c. the third order; 27. *Fungi*, Mushrooms, the fourth order; in the class CRYPTOGAMIA.

In the class CRYPTOGAMIA two other orders are reckoned, *viz.* HEPATICÆ, small herbaceous plants resembling Mosses; and MISCELLANEÆ, including plants not easily referable to any of the five foregoing orders.

The orders, or subdivisions of the classes, are generally marked by the number of the pistils, or by some other circumstance equally intelligible. The names of these, as well as of the classes, are both of Greek derivation, and designate the functions of the respective organs. A further division of the orders, founded on distinctions in the nectarium, lead to *genera.* Other divisions of the genera, in regard to the root, trunk, leaves, &c. lead to *species;* and casual difference in species are called varieties.

We have, in the American reed, an instance of the Monandria monogynia, that is, a flower with one stamen and one pistil. In the jasmine we see an instance of the Diandria monogynia, or flower that has two stamens and one pistil. In the linum or flax, there are five stamens and five pistils; and the flower is called Pentandria pentagynia, that is, one having five males and five females; and so of the rest.

The study of Botany has been applied as a guide to estimate the qualities of plants. The first order of the fourteenth class, denominated "Didynamia gymnospermia," are all innocent or wholesome; those of the other order are febrile, narcotic, and dangerous, being allied to a large part of the Pentandria monogynia, known to be poisonous, as containing henbane, nightshade, and tobacco. The whole class Tetradynamia is wholesome. Whenever the stamens are found to grow out of the calyx, they indicate the pulpy fruits of such plants to be wholesome, except the seeds of the laburnum, which, if eaten unripe, are violently emetic and dangerous. Milky plants are generally to be suspected. Umbelliferous plants, which grow in dry or elevated situations, are aromatic, safe, and often wholesome, while those that inhabit low and watery places are among the most deadly poisons.

The natural substances found in all vegetables are, sugar, in the sugar-cane, beet, carrots, &c.; gum, or mucilage, oozing from many trees; jelly, procured from many fruits; turpentine and tar, from the pine; bitters, from hops and quassia; and the narcotic principle from the milk of poppies, lettuce, &c.

The vegetables of greatest value to man, produce gluten or starch; as wheat, potatoes, barley, beans, &c. Oils are produced by pressing the seeds or kernels of vegetables; as olives, almonds, linseed, &c. Volatile oils are distilled from peppermint, lavender, &c. Wax is collected from all flowers by bees. Resins exude like gum from firs and other trees; and are known as balsams, varnishes, turpentine, tar, pitch, &c. Of this class too, is Indian rubber; which is a gum that exudes from a certain tree in South America. And iron also mixes with the substance of most vegetables, and is the cause of the beautiful colours of flowers. Potash is obtained from the ashes of burnt vegetables; as kelp, vine, fern, &c.

Anatomy of Plants.—In order to comprehend this subject, the following general principles may be of service; they may be verified in most plants; and observation is here the best teacher. First, all plants do not perspire. 2. That there is not in all plants an uniform circulation of sap. 3. In general, the spiral wire is the muscle of the plant. 4. The leaves are for the most part the lungs of the plant. 5. The different divisions of the leaves are formed of the elongations of the bark and inner bark vessels. 6. Hairs and instruments of that kind are the means which Nature takes to form the different juices according to their various affinities. That these figures were taken for perspiration, but are in reality liquids received from the atmosphere and flowing into the plant, not a juice running from it. 7. The root is the grand laboratory of all plants, where the great chemical operations are going on. 8. The heart of the seeds is formed in the extremities of the side roots. 9. The flower is also formed in the middle root, and the pollen in the tap root. 10. The corolla of a flower is formed by bubbles of water placed in rows, and owes all its beauty, and the lightness of its tint, to the refraction and reflection of the sun on the drops of water which form its pabulum. This thought of apparent subtilty is nevertheless verified by experiment. 11. The roots and leaves of a plant will most exactly mark not only what is the soil in which they originally grew, but the situation from which they came, whether a water plant or a dry plant, a rock or a valley plant, &c. 12. The water, semi-water, and rock plants alone can be said to have direct air-vessels, though these may be found in parasite and early spring plants, such as the crocus and hyacinth.

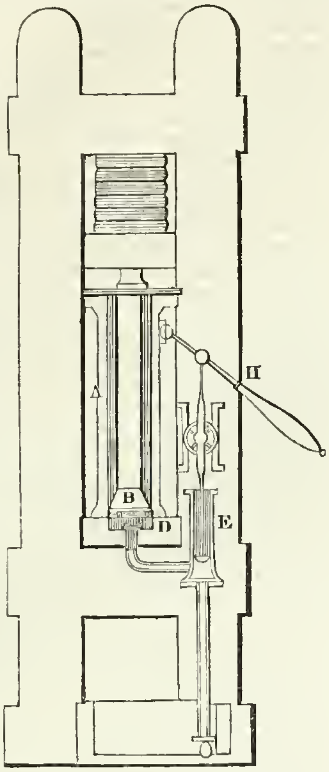
BOWSPRIT, a large boom or mast, which projects over the stem, to carry sail forward, and counteract the force of the aftersails, or those extended behind. The bowsprit should be two-thirds of the length of the mainmast, and its thickness equal to the mizenmast: when it is twelve fathoms five feet long, its yard must be eight fathoms two feet long, and the topmast of the bowsprit three fathoms and one foot.

BOYLE, ROBERT, one of the greatest philosophers of the seventeenth century, was born at Lismore, in Ireland, January 25, 1626, the year in which the sciences were deprived of their greatest ornament, Lord Bacon, whose plans of experimental philosophy our author afterwards so ably seconded and improved. Boyle was one of the first of those illustrious men who formed the Royal Society, in 1645, for the purpose of improving experimental knowledge, upon the plan laid down by Bacon; which society being, in 1654, removed to Oxford, he went to reside there, where he very much improved the air-pump, which led him to the discovery of several of the properties of air. He also published, during his residence at Oxford, several works relating to the properties of air, and other philosophical subjects; and in 1668 returned to London, where he continued to reside till his death, which happened in the year 1691, in the 65th year of his age. Boyle was author of a very great number of important works, beautiful editions of which have been published in London, in five volumes folio, and six volumes quarto. Dr. Shaw also published, in three volumes quarto, the same works "abridged, methodized, and disposed under the general heads of Physics, Statics, Pneumatics, Natural History, Chemistry, and Medicine;" to which he has prefixed a short catalogue of the philosophical writings, according to the order of time when they were published, &c.

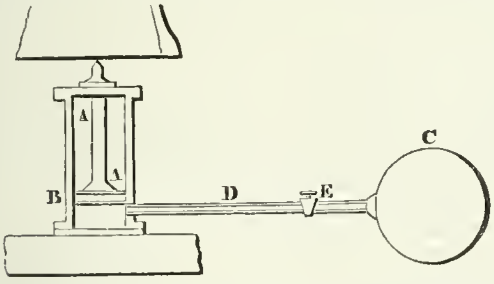
BRAHE, TYCHO, a famous Danish astronomer, born of a noble family, in Knudstorp, 1546, read lectures on astronomy at Copenhagen, in 1574, by order of the king; who also built for him an observatory in the isle of Huen in the Sound, the building being called Uranibourg, where he resided about 20 years, pursuing his studies, making observations, and receiving visits from the most illustrious personages. On the death of the king he lost his pension, and went to Prague, where he was introduced to the emperor Rodolphus: who treated him respectfully; gave him a magnificent house, fit for astronomical observations; and assigned him a pension of 3000 crowns. Here then he settled in the latter part of 1598, with his sons and scholars, and among them the celebrated Kepler. But he did not long enjoy this happy situation; for, about three years after, he died, in the 55th year of his age, and was interred in a very magnificent manner in the principal church at Prague, where a noble monument was erected to him; leaving, beside his wife, two sons and four daughters. The skill of Tycho Brahe in astronomy is universally known, and his works are very numerous and valuable.

BRAMAH'S MACHINE, or *Hydrostatic Press,* &c. consists in the application of water, or dense fluids, to engines, so as, in some instances, to cause them to act with immense force; in others, to communicate the motion and powers of one part of a machine to some other part of the same machine; and, lastly, to communicate the motion and force of one machine to another, where local situations preclude the application of other methods of connexion.

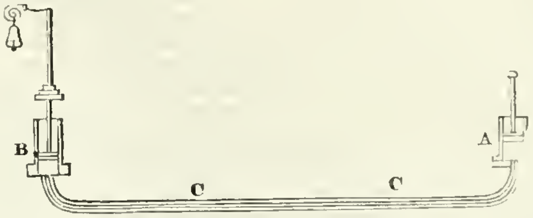
The first and most material part of this invention will be clearly understood by an inspection of the figure in the next page, where A is a cylinder of iron, or other materials, sufficiently strong, and bored perfectly smooth and cylindrical; into which is fitted the piston B, which must be made perfectly water-tight, by leather or other materials, as used in pump-making. The bottom of the cylinder must also be made sufficiently strong with the other part of the surface, to be capable of resisting the greatest force or strain that may at any time be required. In the bottom of the cylinder is inserted the end of the tube C; the aperture of which communicates with the inside of the cylinder, under the piston B, where it is shut with the small valve D, the same as the suction-pipe of a common pump. The other end of the tube C communicates with the small forcing-pump or injector E, by means of which, water or other dense fluids can be forced or injected into the cylinder A, under the piston B. Now, suppose the diameter of the cylinder A to be 12 inches, and the diameter of the piston of the small pump or injector E only one quarter of an inch, the proportion between the two surfaces or ends of the said pistons will be as 1 to 2301; and supposing the intermediate space between them to be filled with water or other dense fluid capable of sufficient resistance, the force of one piston will act on the other just in the above proportion, *viz.* as 1 is to 2304. Suppose the small piston in the injector to be forced down when in the act of pumping or injecting water into the cylinder A, with the power of 20 cwt. which could easily be done by the lever H; the piston B would then be moved up with a force equal to 20 cwt. multiplied by 2304. Thus is constructed a hydro-mechanical engine, whereby a weight amounting to 2304 tons can be raised by a simple lever, through equal space, in much less time than could be done by any apparatus constructed on the known principles of mechanics; and it may be proper to observe, that the effect of all other mechanical combinations is counteracted by an accumulated complication of parts, which renders them incapable of being usefully extended beyond a certain degree; but in machines acted upon or constructed on this principle, every difficulty of this kind is obviated, and their power subject to no finite restraint. To prove this, it will be only necessary to remark, that the force of any machine acting upon this principle can be increased *ad infinitum*, either by extending the proportion between the diameter of the injector and the cylinder A, or by applying greater power to the lever H.



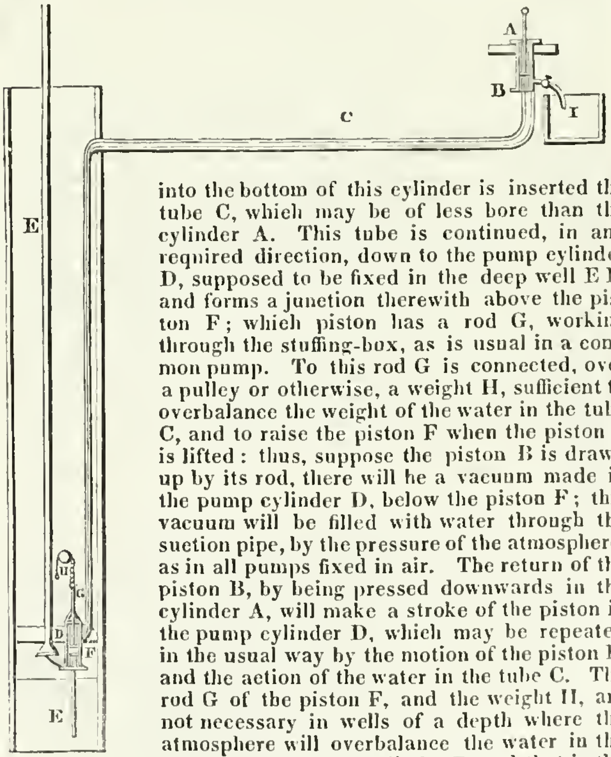
The second figure represents the section of an engine, by which very wonderful effects may be produced instantaneously by means of compressed air. A A is a cylinder, with the piston B fitting air-tight, in the same manner as described in the first figure. C is a globular vessel made of copper, iron, or other strong materials, capable of resisting immense force, similar to those of air-guns. D is a strong tube of small bore, in which is the stop-cock E. One of the ends of this tube communicates with the cylinder under the piston B, and the other with the globe C. Now, suppose the cylinder A to be the same diameter as that in the first figure, and the tube D equal to one quarter of an inch diameter, which is the same as the injector, in the same figure; then, suppose that air is injected into the globe C, (by the common method,) till it presses against the cock E with a force equal to 20 cwt. which can easily be done; the consequence will be, that when the cock E is opened, the piston B will be moved in the cylinder A A with a power of force equal to 2304 tons; and it is obvious, as in the case in the first figure, that any other unlimited degree of force may be acquired by machines or engines thus constructed.



The third figure is a section, merely to shew how the power and motion of one machine may, by means of fluids, be transferred or communicated to another, let their distance and local situation be what they may. A and B are two small tubes, smooth and cylindrical; in the inside of each of which is a piston, made water and air tight, as in the first and second figures. C C is a tube conveyed under ground, or otherwise, from the bottom of one cylinder to the other, to form a communication between them, notwithstanding their distance be ever so great; this tube being filled with water or other fluid, until it touch the bottom of the piston; then, by depressing the piston A, the piston B will be raised. The same effect will be produced *vice versa;* thus, bells may be rung, wheels turned, or other machinery put invisibly in motion, by a power being applied to either.



The fourth figure is a section, shewing another instance of communicating the action and force of one machine to another; and how water may be raised out of wells of any depth, and at any distance from the place where the operating power is applied. A is a cylinder of any required dimensions, in which is the working piston B, as in the foregoing examples: into the bottom of this cylinder is inserted the tube C, which may be of less bore than the cylinder A. This tube is continued, in any required direction, down to the pump cylinder D, supposed to be fixed in the deep well E E, and forms a junction therewith above the piston F; which piston has a rod G, working through the stuffing-box, as is usual in a common pump. To this rod G is connected, over a pulley or otherwise, a weight H, sufficient to overbalance the weight of the water in the tube C, and to raise the piston F when the piston B is lifted: thus, suppose the piston B is drawn up by its rod, there will be a vacuum made in the pump cylinder D, below the piston F; this vacuum will be filled with water through the suction pipe, by the pressure of the atmosphere, as in all pumps fixed in air. The return of the piston B, by being pressed downwards in the cylinder A, will make a stroke of the piston in the pump cylinder D, which may be repeated in the usual way by the motion of the piston B, and the action of the water in the tube C. The rod G of the piston F, and the weight H, are not necessary in wells of a depth where the atmosphere will overbalance the water in the suction of the pump cylinder D, and that in the tube C. The small tube and cock in the cistern I are for the purpose of charging the tube C.—By these means, it is obvious, most commodious machines, of prodigious power, for tearing up trees, &c. and susceptible of the greatest strength, may readily be formed. If the same multiplication of power be attempted by toothed wheels, pinions, and racks, it



is scarcely possible to give strength enough to the teeth of the racks, and the machine becomes very cumbersome and of great expense. But Mr. Bramah's machine may be made abundantly strong in a very small compass. It only requires very accurate execution. Mr. Bramah, however, was greatly mistaken, says Dr. Gregory in his Mechanics, when he published it as the discovery of a *new* mechanic power. The principle on which it depends has been *well known* for nearly two centuries; and it is matter of surprise that it has never before been applied to any useful practical purpose.

BRANDY. The genuine spirit is distilled from wine, (properly so called, being the wine of grapes,) also from the lees of wine, and the husks of the grapes which remain after pressing out the juice. The usual apparatus is employed, of a still that holds five or six quintals, with a capital and worm applied in the usual manner. Brandy has a purer and more vinous taste than other spirits; its peculiar flavour, no doubt, depends on the nature of the volatile principles, or essential oils, that rise in distillation with the pure spirit, and likewise in some measure upon the wood of the cask in which it is kept. The brandies made in France are much preferred to those of Spain and other countries. This preference is, perhaps, as much owing to superior distillation, as to certain peculiarities in the flavour of the grapes, which differ on every soil and in every climate. In the south of France alone, there is a great variety in the grapes, as well as in the quality of the spirit extracted from them. Some wines are considered totally unfit for distillation; others peculiarly suited for it, and unfit for wine. When the fermentation has proceeded too far, the wine is put into the still, and the spirit extracted; otherwise the acetous acid, by the continuance of the fermentation, would be soon produced in such abundance, as to turn the whole liquid into vinegar. The inferior weak wines are generally employed for the making of brandy, from their containing too little spirit to keep them; and the good, strong wines, are generally reserved as yielding a far ampler profit than could be obtained by the extraction of their spirit. The most spirituous wines of France, are those of Languedoc, Guienne, and Rousillon, which yield, according to Chaptal, from twenty to twenty-five gallons of excellent brandy out of a hundred; but those of Burgundy and Champagne much less. Brisk wines, which contain much carbonic acid, from the fermentation having been stopped at an early period, yield the least spirit. The brandies generally esteemed as the best and finest flavoured are those distilled from the grapes which are the produce of the territories of Cogniac and Andaye. Hence every wine merchant in England is professedly stocked with the "real Cogniac" brandy; and thus every public-house sells no other brandy than the "best Cogniac;"—even the distiller himself has the "genuine Cogniac," which he will tell you he has received "circuitously," and truly so, for it has made all the revolutions of his still-worm in its passage to him. In distillation, the three principal distinctions, in the various strengths of spirits, are described by the terms, low wines, proof spirit, and alcohol. Low wines consist of one-sixth of pure spirit, or alcohol, to five of water;—proof spirit consists of one half of alcohol, and one half of water; and alcohol, wholly of pure spirit.

BRANDENBURGIUM SCEPTRUM, the Sceptre of Brandenburg, is a modern constellation, formed in 1688, by Geoffroi Kirch, one of the first astronomers of the Duke of Prussia. This asterism is easily distinguished by four stars, situated nearly perpendicular to the equator, and lying between the turn of the river Eridanus, Orion, and the Hare; and these constellations define the boundaries of this *insigne regiminis.*

BRASS, *Making of.* Brass is a factitious metal, made of copper and zinc. By long calcination alone, and without the mixture of any other substance, brass affords a beautiful green or blue colour for glass; but if it be calcined with powdered sulphur, it will give a red, yellow, or chalcedony colour, according to the quantity and other variations in using it. Brass is of a yellow colour, more fusible than copper, and not so apt to tarnish. Pure brass is not malleable unless hot; when cold it will break, and will not bear the hammer when it has been twice melted. To render it soft and pliable, and capable of being wrought, seven pounds of lead are added to an hundred weight of brass. It is peculiarly adapted for wire, being capable of great extension, and is much used in watch-work. Corinthian brass, so famous in antiquity, was a mixture of gold, silver, and copper. Brass colour is a preparation intended to imitate brass; of which there are two sorts, the red brass or bronze, and the yellow or gilt brass; the last is made only of copper filings; with the former, red ochre, finely pulverized, is mixed, but both are used with varnish. The appearance of brass is given to other metals, by washing them with a yellow lacquer or varnish, much to the detriment of the manufactured article.

Gold lacquer for brass-work may be thus made:—Put an ounce of turmeric powder, two drachms of anatto, and two of saffron, into a pint of alcohol, shake the whole occasionally during a week, and then filter it into a clean bottle. Three ounces of clean seed-lac are then to be added, and the bottle shook occasionally during a fortnight. The mixture will now be a fine lacquer for brass, which will give that metal the appearance of burnished gold. In using it, the metal should be just warmed, and the varnish be laid on evenly with a brush, passing it directly across the work. Small articles may be dipped in the lacquer.

BREAD, the staff of life, is used by all people in one way or another, even though composed of materials very dissimilar. We use wheaten bread; some use bread made of oats, others convert dried fish into meal for bread; and nature furnishes the bread-fruit tree to natives of the South-Sea islands.

The bread-fruit tree grows abundantly on the Ladrone Islands. In the Society Islands it is as large as a moderate sized oak; its leaves are about a foot and a half long, of an oval shape, like those of the fig-tree, which they resemble in colour; and, when broken, exude a milky juice. The fruit is shaped like a heart, and grows to the size of a child's head. Its rind is thick, green, and covered with excrescences. The internal part of the rind is a pulpy substance, full of twisted fibres; this pulp is softer towards the middle, where a small cavity is formed, containing no kernels or seeds. It affords much nourishment, and is very satisfying. Its taste is harsh, and similar to potato-bread. The cassiva bread of the Americans is made from a species of starch prepared from the roots of a plant. They are peeled and pressed; the juice which exudes is a deadly poison, used by the Indians to poison their arrows. The white starch, however, which is deposited, when properly washed, is perfectly innocent, and makes bread.

The materials of which loaf-bread is principally made, are the seeds of farinaceous vegetables, as wheat, rye, and barley. Potatoes, oats, beans, pease, rice, maize, millet, buck-wheat, &c. contain no gluten, and cannot be made into bread without a certain quantity of flour. The component parts of wheaten, barley, and rye flour, are starch, gluten, and saccharine mucilage.

Fecula, or starch of wheaten flour, forms the most nutritive part of grain. It is found in all seeds, and is very abundant in the potato, as almost all the root consists of starch. 2. Gluten, is the principal substance contained in wheaten flour. It is necessary for the production of good light bread; the quality of the bread being exactly in proportion to the quantity of the gluten contained in the flour: wheat flour alone contains it in any considerable quantity. Flour could not be made into bread without gluten, for the dough rises in consequence of this substance. To obtain gluten, you put a handful of flour into a cloth, pass it through water, and press it with the hand; the starch or fecula passes off, and this elastic substance remains. Gluten forms one-fifth part of bread-corn, ferments readily, and is soluble in acids, but not in water. 3. Saccharine mucilage is soluble in cold water, and separable from it by evaporation. The saccharine part may be converted into an ardent spirit, but the mucilage in bread that has been kept some time, tends to acidity, and becomes mouldy. There are three general methods of making bread, and these we will now illustrate:—1. Unleavened bread is made of flour mixed with water. The sea and other biscuits, the Jews' passover cake, the oaten and barley bread of Scotland, are of this nature. 2. Leavened bread, mentioned in the Jewish history, has been known to mankind from the earliest age of society. It is thus made: A portion of dough is left till it ferments, or becomes sour. This is mixed with other dough, and causes it to rise: carbonic acid gas is thrown out, a vinous smell is perceived; and an active fermentation goes on. 3. Bread made with yeast, or family bread, is thus made. To half a bushel of wheaten flour add six or eight ounces of salt, a pint of yeast, and six quarts of water. Mix the whole together, and cover it up with a blanket; this operation is called setting the sponge: flour must then be added, and the mass kneaded till it attain a proper consistency. It must then stand for four or five hours, till it rises properly, and afterwards you put it into the oven.

A sack of flour contains about 280 lbs. and will make eighty quartern loaves, allowing three and a half pounds of flour for each. Before the loaf goes into the oven it weighs 4 lbs. 15 oz. but loses nine or ten ounces in baking. In each loaf bakers usually put two ounces of alum, though this is prohibited by law. The alum binds the bread, and makes it more compact, but then it is less wholesome; and it also whitens old flour. Besides the bread just described, there are wheaten and household bread. The former is made of flour, with a mixture of the finer bran; the latter of the whole substance of the grain, without either taking out the coarse bran or the fine flour.

French bread is made by adding ten eggs, and a pound and a half of fresh butter, and as much yeast, to half a bushel of fine flour. The whole mass is tempered with new milk, warmed pretty hot; after being allowed half an hour to rise, it is made into loaves, or rolls, and is washed over with an egg beaten with milk; the oven is of a gentle heat. Bread is highly nutritious. And since, among the animal fluids the saliva is essentially necessary, dry food should be used as a stimulus to draw it forth; thence we eat bread with meat. Bread blends the oil and water of food in the stomach, which it stimulates; and it is peculiarly proper for that purpose, being bulky without too much solidity, and firm without difficulty of solution.

BREAKWATER, a sort of small buoy fastened to a large one, when the buoy-rope of the latter is not long enough to reach to the surface of the water; and thereby to shew where the large buoy swims. Breakwater signifies also the hull of an old ship sunk at the entrance of a small harbour, to break off or diminish the force of the waves as they advance towards the vessels moored within. The great Breakwater across the bay of Plymouth, which has been going on for years, and is not yet finished, is the greatest of the kind ever undertaken in the kingdom. The exposed situation of the sound has been long and severely felt as an extreme inconvenience in the harbour, and it was at last determined to oppose, if possible, some barrier to the heavy swell which is here almost continually rolling in from the Atlantic. The plan at last adopted, with the advice of the most experienced engineers, men of science, and naval officers, was, to construct at St. Carlos rocks, about three miles south of Plymouth, a mole, or vast heap of stones, in the middle of the sound, stretching across its entrance, occupying nearly half of its width, and leaving a free passage for vessels, both on the eastern and western shores. The whole expense was estimated at £1,171,100, *viz.* £1,051,200 for the mole or breakwater, and £119,900 for a pier along the top, with lighthouses. It was proposed, that the breakwater should begin 360 feet on the eastward of St. Carlos rocks, and extend 1800 feet west of the Shovel rock; the whole length to be 1700 yards, or very nearly a mile, 4000 feet in the middle being quite straight, and the two extremities having a slope up the sound. It was estimated, that 2,000,000 tons of stone would be required to finish it; and it was advised to heap them promiscuously together in large blocks, not less than 1½ or 2 tons weight each, leaving them to find their own base and position. Where the water was 30 feet deep, the dimensions of the breakwater were to be 40 feet high, 30 feet across the top, and 210 feet wide at the foundation. The work was begun in 1812; the first stone was sunk on the 12th of August; and on the 31st March, 1813, the building began to make its appearance above the surface of low water at spring tides. The stones were quarried from a rock of limestone or gray marble, purchased from the Duke of Bedford for £10,000, and situated on the eastern shore of Catwater. More than fifty vessels, of peculiar construction, were employed in carrying the stones to the work, many of which were five tons and upwards each. On the whole, this great work has been conducted with much skill and surprising despatch, and the result has fully answered the expectations of its projectors. At the end of the second year, the swell was so much broken, that ships of all sizes ran in, and anchored with confidence behind the breakwater. Since that time 200 sail of vessels of every description have here found shelter, and 25 or 30 sail of the line may now ride here at all times, in security. The Eddystone lighthouse is an important appendage to the harbour, without which the entrance to the harbour would be extremely dangerous. *See* EDDYSTONE.

BREAMING, burning off the filth, such as grass, ooze, shells, or sea-weed, from the ship's bottom, which it has contracted by lying long in harbour; it is performed by holding kindled furze, faggots, or reeds, to the bottom, which, by melting the pitch that formerly covered it, loosens whatever filth may have adhered to the planks; the bottom is then covered anew with a composition of sulphur, tallow, &c. which not only makes it smooth and slippery, so as to divide the fluid more readily, but also poisons and destroys those worms which eat through the planks in the course of a voyage. This operation may be performed either by laying the ship aground after the tide has ebbed from her, or by docking, or careening.

BREWING. Brewing is a very ancient domestic art. Before the malt is used it must be bruised between rollers; and soft water is used for mashing and fermentation. The first step in brewing is mashing. This is done in a tub furnished with a false bottom, pierced with holes, and moveable, or fixed a few inches above the real bottom. There are two side-openings between the two; to one is fixed a pipe to convey water into the tun, and the other is used for drawing the liquor out. The malt is to be strewed over the false bottom, and a proper quantity of water let in from the upper copper; after which, the mass is beaten by poles, or a machine like a rake or harrow, and moveable on a perpendicular beam, with transverse arms for the rakes. When the mashing is completed, the tun is covered to prevent the escape of the heat, and the whole is suffered to stand, that the insoluble parts may separate from the liquor; the side-hole is then opened, and the clear wort discharged into the lower copper. The most eligible temperature in mashing is from 185 to 190 degrees, but for the first mashing the heat of the water must be less, and so in proportion to the dark colour of the malt.

The wort of the first mashing is always the richest in saccharine matter; but to exhaust the malt, a second and third mashing are requisite.* Thirty gallons may be drawn from each bushel of malt, for sound small beer; six and a half gallons only for strong ale. Every bushel of malt absorbs, or retains, about three and a half gallons of water. The next process is boiling and hopping; if only one kind of liquor is to be made, the produce of the three mashings should be mixed; if both ale and table-beer are required, the wort of the first, or first and second mashings, is for the ale, and the remainder for the beer. The wort intended for the same liquor, after it comes from the tun, is put into the lower copper, and mixed with a proportion of hops; and the better the wort, the greater the quantity of hops will be wanted. Hops contain gallic acid and tanning matter, and deprive the sweet wort of the mucilage, which occasions the beer to keep without turning sour. After the hops have been mixed with the wort in the copper, the liquor is made to boil as fast as possible, when it is discharged into shallow tubs, called coolers, where it remains till it is cool enough to undergo fermentation.

From the coolers the liquor is transferred to the working tun, and with it is mixed a gallon of yeast to four barrels of beer. In four or five hours the fermentation commences, but it requires from 18 to 48 hours before the wort is fit to be barrelled. The fermentation still goes on in the barrels, and in a few days a copious discharge of yeast takes place from the bung-hole, and the greater portion of gluten is disengaged. In brewing, the gluten is not wanted, but in bread is indispensable, and alone renders it fit for use. Care must be taken to fill up the barrel every day with fresh liquor; this discharge lessens daily, and ends entirely in about a week, when the bung-hole is closed, and the liquor is fit for use, after standing from a fortnight to three months, according to its strength, and the temperature at which it has been fermented. The fining of the beer is done by the use of isinglass. But drugs are sometimes used, to give a narcotic and stupefying power to the beer.

---

* Brewers use a sacchrometer to ascertain the goodness of the wort. This instrument is a kind of hydrometer, and shews the specific gravity of the wort, rather than the exact quantity of saccharine matter contained in it.

Ale, a fermented liquor extracted from malt, has a less proportion of hops than beer. It was first made in Egypt as a substitute for wine, and was a favourite drink with the Anglo-Saxons and Danes. Pale ale is accounted more wholesome than brown ale, because it is brewed from malt slightly roasted, while the latter is made of drier malt.

To make malt, barley is steeped in cold water, not less than 40 hours. When it is sufficiently steeped, the water is drained off, and the barley spread upon the malt floor, where it is formed into a rectangular heap, about 16 inches deep. In this state it remains about 26 hours. It is then turned with wooden shovels, and diminished in depth: this is repeated twice or thrice a day, and the grain is constantly spread, till its depth does not exceed a few inches. On the couch it absorbs oxygen from the atmosphere, which it converts into carbonic acid; the temperature gradually increases, and in four days the grain, now ten degrees hotter than the atmosphere, becomes moist, and exhales an agreeable odour: this is termed the sweating. The maltster must keep the temperature from becoming excessive, by turning. At the period of sweating, the roots of the grains appear. In one day after the sprouting of the roots, the rudiments of the future stem, called the acrospire, may be seen to lengthen. As it shoots along the grain, the mealy part undergoes a considerable change: the glutinous and mucilaginous matter is taken up and removed, the colour becomes white, and the texture so loose that it crumbles to powder between the fingers. When the acrospire has come nearly to the end of the seed, the process is stopped by drying the malt upon a kiln. It is then cleaned. When the grain is dried gradually, or in the sun, it is called air-dried malt; or when quickly, by the heat of a stove, kiln-dried; the latter being charred partially, is brown, more or less intense, and contains less fermentable matter than the air-dried, or pale malt. Burnt sugar is frequently used to colour beer.

BRIDGE, an artificial mode of conveyance from one part of space to another, the intermediate part being either impassable, or difficult, or otherwise of inconvenient access. Among the ancients, the Greeks borrowed, with their science, their knowledge of architecture, and consequently of bridge-making, from the Asiatics; and of these last, the Chinese attained a degree of perfection which neither Greece nor Rome could boast. From time immemorial, chain bridges have passed from acclivity to acclivity, a distance in some instances of 600 feet, the height of the arch being 750 feet; and this in one span!

The bridge (of wood or boats) that Darius built over the Propontis, or the Dardanelles, to pass from Asia into Europe, surpasses all the modern military bridges. But this is outdone by the bridge of Trajan over the Danube, which one cannot sufficiently admire; for though all the works of this emperor were magnificent, yet this structure, 4770 feet long, supported by twenty piers of square stone, each pier 150 feet high above the foundation, 60 feet in breadth, and 170 feet from each other, does equal honour to the wise policy of the Roman, and his eastern architect, Apollodorus of Damascus.

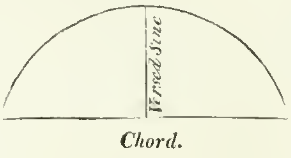
Among the moderns, Belidor, an engineer, directs that the piers be one-fifth, or at least one-sixth, of the opening: and the arch stones $\frac{1}{34}$th part of the opening: in general, that the pier ought to be of that strength, that it will support its arch as an abutment; which, by practice, he finds to be one-fifth or one-sixth; but gives as a rule, one-sixth and two feet more. For example, an arch of 36 feet should have a pier of $\frac{36}{6} + 2 =$ 8 feet. In an arch of 72 he makes the pier 14 feet, *viz.* two feet more than one-sixth.

Gautier, another engineer, differs only from Belidor as to the length of the arch stones; which in arches of 24 feet ought to be 2 feet; if 45, 3 feet; if 60, 4 feet; if 75, 5 feet; if 96, 6 feet, when the stone is of a durable material; but of greater dimensions, when the stone is soft, and easily decomposed: and an arch stone of 6 feet, of durable material, will suffice for an arch of 150, or even 200 feet. *See, in the sequel, A Table for the Thickness of Bridges.*

London Bridge, (see Plate, *Bridges*,) planned by Peter of Collchurch, a priest, has its piers much stronger, being more than half the opening; the piers being from 25 to 34 feet, 18 in number, the width of the river being only 900 feet. This bridge is now being supplanted by a more capacious structure, which has this year, 1824, been begun to be built; and of which we shall speak in the close of this article.

The piers of *Westminster Bridge*, (see Plate, ***Bridges***,) are 17 feet, the breadth of the river 1223 feet, the arches semicircular; the spring commencing about two feet above low-water mark. There are thirteen large and two smaller arches; the centre arch is 76 feet span, and the others decrease on each side by four feet. The passage for carriages is of very difficult ascent, the rise being 30 feet in a distance of 611·5 feet. The whole width is 44 feet, and ledges, balustrades, and semi-octagon recesses, or towers, with the well-paved footpath, give this bridge an elegant appearance.

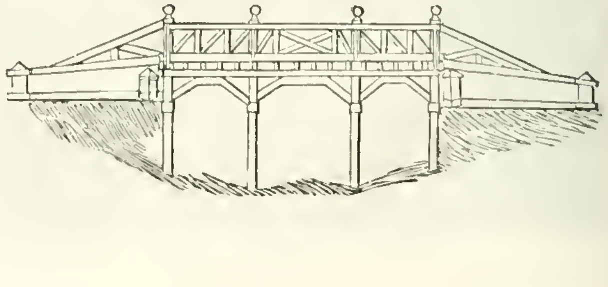
Blackfriars' Bridge, (see Plate, *Bridges*,) has elliptical arches, and no precaution was neglected that could contribute to its strength, or give addition to its elegance. In the middle arch, which is of 100 feet span, the flat part of the arch is described with a radius of about 57 feet; the lesser circles on either side being $35\frac{3}{4}$, or 36 nearly. This small arch is continued below its diameter, till its chord, as in the annexed figures, become 16 feet nearly, and its versed sine 5 feet nearly, which gives it the degree of novelty alluded to; and which is far from being disagreeable to the eye. The shoulders are compactly filled with ruble work, the bed of each row tending to the centre of the arch. To the height to which the arch can be raised without a supporting frame, an inverted semicircle is drawn, the convexity of the arch resting upon this ruble work, which is formed of Kentish rag; but other hard stone will equally well answer this purpose, as that cannot be every where procured. The inverted arch answers two purposes; it prevents this ruble being raised by any lateral pressure, and makes those parts of the arch which form the greatest lateral pressure, abut upon each other: hence there is little or no lateral pressure upon the pier.



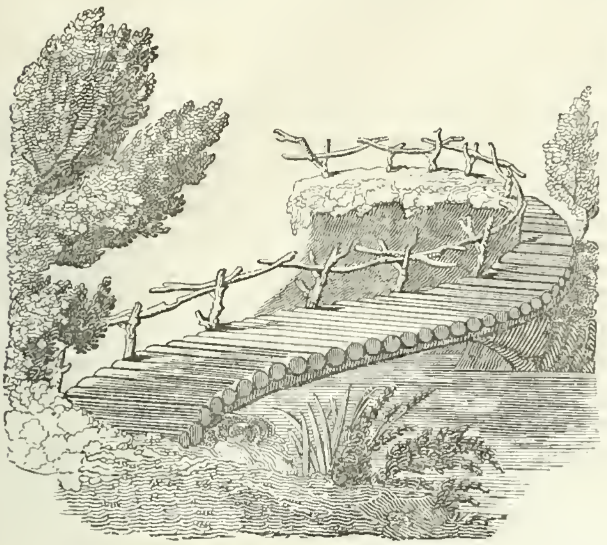
The bridge of Burton-on-Trent is the longest in Britain, being 1545 feet, supported on 34 arches: the most stupendous in Europe, that over the Tave in Glamorganshire, consisting of only one arch, the segment of a circle whose diameter is 175 feet; the chord of the segment, or span of the arch, 140 feet, the height or vertical sine 35 feet; the abutments 32 feet: the architect was William Edward, a country mason: it was built in 1756.

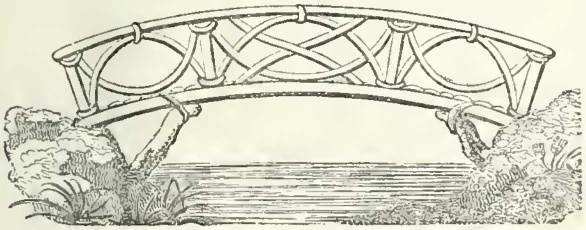
The Rialto at Venice, built by Michael Angelo, is reckoned a masterpiece of art, on account of its flatness and extent, being $98\frac{1}{2}$ feet span, and 23 feet only above the water; but this is far outdone by many bridges of modern erection.

Wooden Bridges. Where stone bridges cannot be constructed, on account of expense, or other causes, very durable ones may be formed of wood: all the parts ought to press on one another like the arch of a stone bridge; and thus, instead of being weakened by great weights passing over them, they will become the stronger. How this is to be effected, will be best understood from the annexed figure.

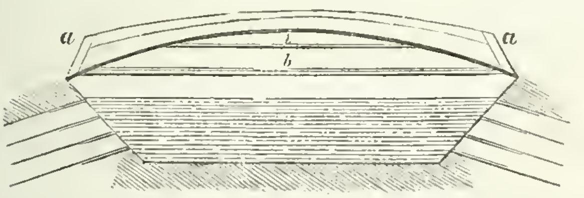


The *Swiss Bridge*, (as represented in the following figure,) a rude composition of trees unhewn, and covered with rushes or boards, serves very well for small streams, canals, &c. in gentlemen's parks, &c. This may be improved by the addition of a rustic balustrade, in the following style.



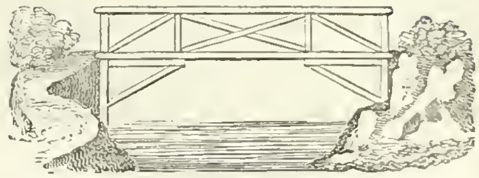


The *Tied-Plank Bridge*, (as in the annexed figure,) is formed by fixing the ends of two or more planks in two heads of iron, *a*, *a*, and then connecting them by wrought iron rods, *b*, *b*, fixed to the heads in the manner of a bow string. A very slight bridge, thus formed, acts both by tenacity and gravity. Thus, when the bridge is but lightly loaded, the particles of the boards are not moved, but merely pressed on, and, therefore, the arched part may be said to act by gravity, while this pressure, being propagated to the abutments, these are held in equilibrium by the iron rods acting by their tenacity. On the other hand, when a bridge of this description is heavily loaded, the arch will bend downwards, or yield in some places, and rise in others; in which case the whole will act by tenacity.



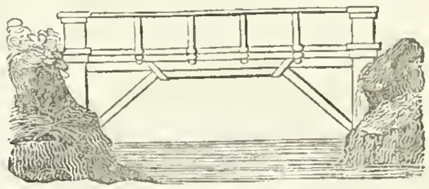
A very light and strong Bridge may be formed by screwing together thin boards in the form of a segment, or by screwing together a system of triangles of timber, as in the following figure. These triangles being equilateral, become in effect so many parts of hexagonal figures, which may be circumscribed by a circle, and thence carried to any extent, though, in the construction, the whole may act more by tenacity than by pressure.

Light Bridge.

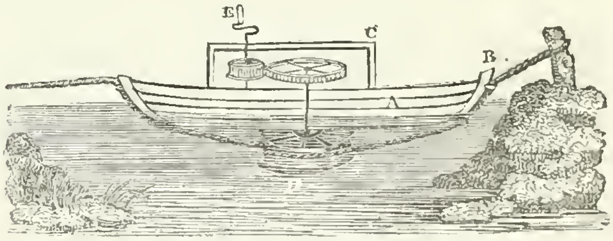


For broad sluggish rivers, swampy ground, &c. such a bridge will do very well, but it is inferior perhaps to the following

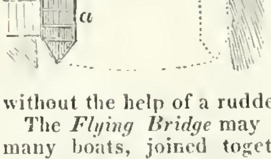
Strong Bridge.



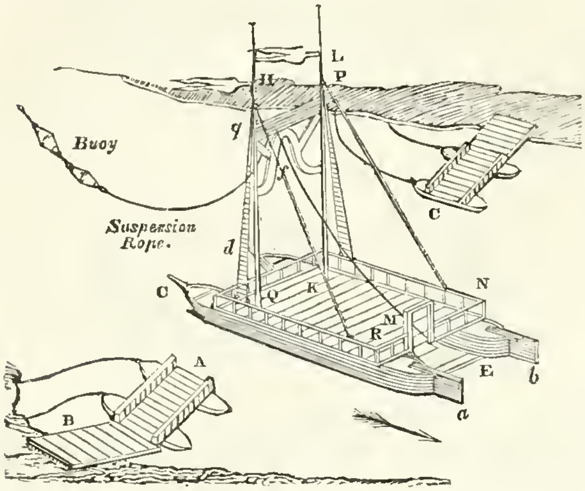
The *Boat Bridge*, as here represented, may be worked by a mechanical power, as the wheel and pinion, or by means of a cylinder and rope B, and machinery fixed in a box C, and connected with the rope D, the vehicle may be moved from one side of a stream to the other, by merely turning the winch E. A contrivance of this kind was devised by Repton, for passing a piece of water in the park of Holkham Hall, Norfolk, the estate of T. W. Coke, Esq.

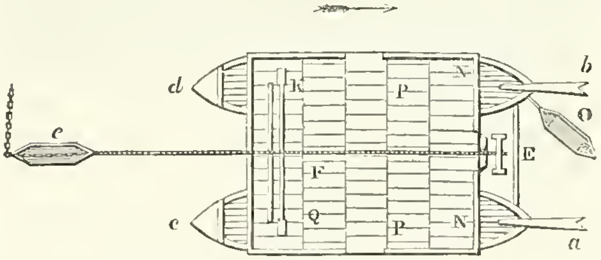


The Flying Boat, as represented in the annexed figure, with the deck arranged as part of the gravel walk, which approaches the edge of the water, derives its motion from the obliquity of its sides to the direction of the current, which must be kept up by the use of a rudder. The force of the stream is at a maximum when the angle formed by it and the side of the boat, is 54° 44′. The boat *a* must be anchored to a post *b*, fixed in the middle of the river, and the longer the cable *c*, the manœuvre will be the more easily executed, provided the movement is not made in a greater arc than 90°. The same purpose may be effected by a triangular raft, without the help of a rudder.

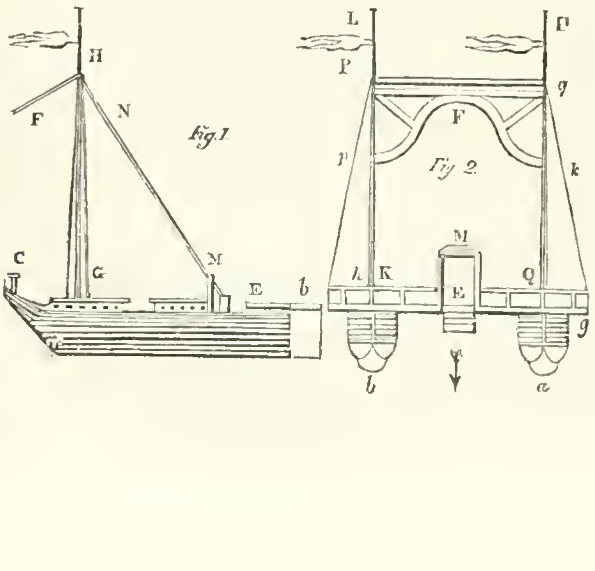


The *Flying Bridge* may be formed of several, or indeed of many boats, joined together and floored with substantial planks, surrounded with a rail or balustrade; and according to its breadth it may have one mast, or two masts, to support a rope at a proper height; one end may turn round a windlass, the other may be fastened to an anchor in mid stream, and may be kept aloft by buoys. As in the former case, the bridge is worked by one rudder, if there is one boat; if more boats, then each may have a rudder, the tillers of all the rudders moving at the same angle. As the stream is narrow or wide, the suspension rope may be shortened or lengthened by the windlass. Such bridges will ferry over cavalry or infantry; but to become defensible by mutual support and augmented strength, several such bridges, at convenient distances, are launched and moored. A B, C D, (in the following figure,) are two long boats which support the bridge; G H, K L, two masts joined at their tops by traverse beams, and a central arch supported in a vertical position, by two pair of shrouds and two chains, L N and H R. M is a horse, or cross piece, upon which the cable M F, *ef*, rests: the use of this has been explained above. The buoys are *e*, *f*. E windlass, *a*, *b*, rudders. A B, C D, two portions of bridges of boats fastened to the banks on each side of the stream, and between which the bridge traverses. The annexed figure is a ground plan of the same bridge. K, Q, the mast holes; E, windlass; N, N, pumps; P, P, capstans. Fig. 1, a lateral elevation of the same; *b*, the rudder; E, the windlass; M, the horse; E, N, H, F, the cable. Fig. 2, is an elevation of the hinder part of the bridge or stern; *a*, *b*, the two boats; Q H, K L, the two masts; H L, the upper traverse beam; *p q*, the lower traverse beam, over which the cable passes, and occasionally slides from one mast to the other; and must on that account be kept well greased. *p k*, *g g*, shrouds; M the cross piece over which the cable passes to the windlass.



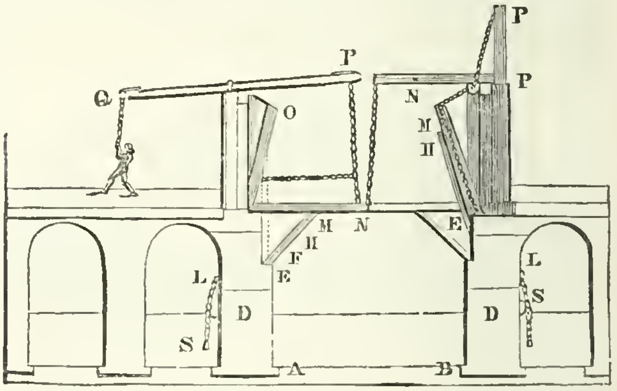


View Fore and Aft.



The *Bushen Bridge*, made of bundles of rushes, serves to afford a passage over marshy ground. And bridges of casks, bottles, bladders, and buoys made of skins, do well for transporting individuals, or even troops, as portable machines.

The *Draw Bridge*, made after the manner of a float, to draw up or let down, as occasions serve, before the gate of a town or castle, may be made after several different ways; but the most common are made with plyers twice the length of the gate, and a foot diameter. The inner space is traversed with a cross, which serves for a counterpoise, and the chains which hang from the extremities of the plyers, to lift up or let down the bridge, are of iron or brass. Such bridges we have seen at Stirling and Edinburgh castles, at the Tower of London, at the castle of Vincennes, and many other regularly fortified places. In navigable rivers it is sometimes necessary to make the middle arch of bridges with two moveable platforms, to be raised occasionally, in order to let the masts and rigging of ships pass through this kind of drawbridge. A B (in the following figure) represents the middle of the arch; A L and B L the two piers that support the drawbridge, N O, one of the platforms of which is raised and the other let down, having the beam P Q for its plyer. To N O are suspended two moveable braces, E H, E H, which resting on the support E, press against the bracket M, and thereby strengthen the draw bridge. These braces are conducted to the rest by means of the weight S pulling the chain S L F.



It will now be necessary to proceed with those details upon which the practical construction of bridges depends; and we will therefore lay down Belidor's Table for the thickness of their piers, agreeably to what has been said above, on the relative proportions between the span of the arch and the thickness and height of the piers.

The first horizontal line expresses the height of the piers in feet, from 6 to 24 feet, each increasing by 3. The first vertical column, the width of the arches from 20 to 100 feet, for every five feet. The other columns express the thickness of piers in feet and decimals, according to the respective height at the head of the columns, and the width of the arch against it in the first column. Thus, *e. g.* let the width of the arch be 60 feet, and the height of the piers 12, then the number 12·718 under 12, and against 60, expresses the thickness of the piers, *i. e.* 12 feet 8 inches $\frac{6}{10}$ths. The length of the key-stone in an arch of 30 feet wide, is 2 feet; 3, 4, 5, 6 feet in an arch of 45, 60, 75, 90.

As this table contains the thickness of the piers in respect to arches that are commonly used in practice, we imagine it would be needless to carry on the table further; because the difference between the thickness of the piers of any two contiguous arches being but small, those between any two marked here may be made equal to half the sum of the next below and above it; thus, the thickness of the piers of an arch 52 or 53 feet wide, is nearly equal to 10·242, half the sum of the thicknesses 9·085 and 10·64, of the arches 50 and 55 feet wide, when the height of the piers is 6 feet.

Table *containing the Thickness of Piers of Bridges.*

	6	9	12	15	18	21	24
20	4·574	4·918	6·165	5·350	5·492	5·610	5·689
25	5·490	5·913	6·216	6·455	6·645	6·801	7·930
30	6·386	6·816	7·225	7·513	7·746	7·939	8·102
35	7·258	7·788	8·200	8·532	8·807	9·037	9·233
40	8·404	8·691	9·148	9·523	9·835	10·101	10·328
45	8·965	9·579	10·077	10·489	10·817	11·316	11·394
50	9·805	10·454	10·987	11·435	11·817	12·148	12·234
55	10·640	11·245	11·882	12·364	13·019	13·149	13·218
60	11·400	12·110	12·718	13·218	13·723	14·109	14·314
65	12·265	13·025	13·648	14·185	14·654	15·082	15·435
70	13·114	13·869	14·517	15·049	15·573	16·011	16·400
75	14·000	14·705	15·336	15·965	16·480	16·940	17·354
80	14·747	15·542	16·234	16·842	17·381	17·864	18·296
85	15·513	16·328	17·041	17·674	18·237	18·742	19·198
90	16·373	17·201	17·429	18·178	19·257	19·679	20·132
95	17·184	17·826	18·771	19·438	20·036	20·577	21·008
100	17·991	18·848	19·620	20·293	20·908	21·468	21·978

Rectangular piers are seldom used but in bridges over small rivers. In all other cases, they project beyond the bridge by a triangular prism, which presents an edge or an angle to the current, in order to divide the water more easily, and to prevent ice and other matters, that float, from sheltering there, as well as vessels from running foul against them. That edge is terminated by the adjacent faces at right angles to each other at Westminster bridge, and makes an acute angle at the Pont Royal of Paris, of about 60 degrees; but of late, the French terminate this angle by two cylindric surfaces, whose bases are arcs of 60° in all their new bridges.

Slope of the Bridge on each side, and Width.—When the banks of the rivers are high, the bridge is level above, and all the arches of an equal width; but where they are low, or for the sake of navigation, a large arch is made in the middle of the stream, and the bridge is higher in the middle than at the ends; the slope easy and gradual on both sides, so as to form one continued curve line. The descent of that slope may be one-fiftieth part of the length.

The width allowed to small bridges is 30 feet; but in large ones, near great towns, 30 feet are allowed clear for horses and carriages, besides a pathway on each side for foot passengers, from 6 to 9 feet broad, raised about a foot above the carriage road; the parapet walls on each side are about 18 inches thick, and 4 feet high, and generally project over the bridge with a cornice underneath. Sometimes balustrades of stone or iron are placed upon the parapet, as at Westminster and Blackfriars' bridges; but this is only practised in bridges of a great length, and near the capital of a country. The ends of bridges, open from the middle of the two large arches with two wings, making an angle of 45 degrees with the vest, in order to make their entrance more free and easy. These wings are supported by the same arches of the bridge next to them, being continued in the manner of an arch, of which one pier is much longer than the other.

The Methods of Laying the Foundation.—Laying the foundation of the pier is the most difficult part of the whole work, except when the depth of the water does not exceed 6 or 8 feet. In shallow water, one of the abutments, with the adjacent piers, is enclosed by a dike of a sufficient width for the work, and room for the workmen. This dam is made by driving a double row of piles, whose distance is equal to the depth of water, and the piles in each row are 3 feet from each other. They are fastened together on the outside by bonds of 6 by 4 inches thick. This done, frames about 9 feet wide are placed on the inside, to receive the boards which are to form the enclosure. The two uprights of these frames are two boards of an inch and a half thick, sharpened below, to be driven into the ground as deep as necessary; then the boards themselves are likewise driven in till they reach the firm ground underneath. Between every two piles, tie-beams are fixed to the ends of the piles, to strengthen the inside wall, and fasten it to the outside one; these tie-beams are let into the bonds, and bolted to the adjacent piles. The bottom is then cleared from the loose sand and gravel, by a machine like that used by ballast-heavers, and then well prepared clay is rammed into this coffer very tight and firm, to prevent the water from oozing through. Sometimes these enclosures are made with piles only, driven close to each other; at others, the piles are notched or dove-tailed one into the other; but the most usual method is to drive piles with grooves in them, 5 or 6 feet distant from each other, and boards are let down between them in these grooves.

Pumps and other engines are now used to draw the water out of the dams or enclosures, till they become quite dry; then the foundation is dug, and the stones are laid with the usual precautions, observing to keep some of the engines always standing, to draw off the water that may ooze through the coffer work. The foundation being cleared, a course of stone is laid on the outside all round, with the largest stretchers and headers that can be had, and the inside filled with ashlers well jointed, the whole laid in terrass mortar; and some cramps are also used to fasten the facings with the inside. The same manner is to be observed throughout all the courses, to the height of low water mark; after which, the facings alone are laid in terrass mortar, and the inside with the best of the common sort. When the foundation has been raised to the height of low-water mark, or to the height where the arches begin, then the shaft or middle wall is to be carried up nearly to the height of the arches, and there left standing till all the piers are finished, in order that the masonry may be sufficiently dry and settled before the arches are begun.

The proper Form of the Base.—As the piers end generally with an arch at each end, it is usual to lay the foundation in the same manner; which is not so well as to continue the base rectangular quite to the ends of the piers, and as high as low-water mark, both because the foundation becomes then so much broader, and also because the water will not be able to get under it; for when the current sets against a flat surface, it drives the sand and mud against it, so as to cover it entirely, whereas if a sharp edge be presented to the stream, it carries every thing away, and exposes the foundation to the continual action of the water, which in course of time must destroy it.

After the intervals between the arches are filled up with stones, laid in a regular manner, without mortar, and the gravel is laid over them; two drains or gutters are made lengthwise over the bridge, one on each side next to the foot-path, about six feet wide and a foot deep, which being filled with small pebble-stones, serve to carry off the rain water that falls on the bridge, and to prevent its filtering through the joints of the arches, as often happens.

Method of Building with Coffers, as was practised at Westminster Bridge, is to build with coffers, when it is preferable, from the depth of water being 6 feet at a medium when lowest, and the tide rises about 10 feet at a medium also, so that the greatest depth of water is about 16 feet. At the place where one of the piers at the middle or great arch was to be, the workmen drove piles of about 13 or 14 inches square, and 34 feet long, shod with iron, so as to enter into the gravel with more ease, and hooped above, to prevent their splitting in driving them home. These piles were driven from 13 to 14 feet below the bed of the river, and 7 feet distant from each other, parallel to the short ends of the pier, and about 30 feet distant from them. The number of these piles was 34, and their intent was, to prevent any vessels or barges from approaching the work; and in order to hinder boats from passing between them, booms were placed so as to rise and fall with the water.

At this stage of the work, the ballast-men dug the foundation under the water, of about 6 feet deep, and 5 wider all round than the intended coffer was to be, with an easy slope, to prevent the ground from falling in. In order to prevent the current from washing the sand into the pit, short grooved piles were driven before the two ends, and part of the sides, about 4 feet higher than low-water mark, and 15 feet distant from the coffer: between these piles, rows of boards were let into the grooves down to the bed of the river, and fixed there.

The bottom of the coffer was made of a strong grating, consisting of two rows of large timbers, the one longways, and the other crossways, bolted together with wooden trunnels ten feet wider than the intended foundation. The sides of the coffer were made with fir timbers laid horizontally close one over another, pinned with oaken trunnels, and framed together at the corners, excepting at the two protruding angles, where they were secured with iron, so that the one half might be loosened from the other, if it should be thought necessary: these sides were lined on the inside, as well as on the outside, with three-inch planks placed vertically; the thickness of those sides was 18 inches at the bottom, reduced to 15 above, and they were 16 feet high; besides, knee-timbers were bolted at the angles, to secure them in the strongest manner. The sides were fastened to the bottom by 28 pieces of timber on the outside, and 18 within, called *straps*, about 8 inches broad and 3 or 4 inches thick, reaching and lapping over the ends of the sides. The lower part of these straps had one side cut dove-tail fashion, to fit mortises made near the edge of the bottom, and were kept in their places by iron wedges; which being driven out when the sides were taken away, gave liberty to clear the straps from the mortises.

Before the coffer was launched, the foundation was examined, to know whether it was level; for which purpose several gauges were made, each of which consisted of a stone of about 15 inches square and 3 thick, with a wooden pole in the middle, of about 18 feet long. The foundation being levelled, and the coffer fixed directly over the place with cables fastened to the adjacent piles, the masons laid the first course of stones for the foundation within it; which being finished, a sluice made near the side was opened at low water, on which the coffer sunk to the bottom; and if it did not set level, the sluice was shut, and the water pumped out, so as to make it float till the foundation was levelled: then the masons cramped the stones of the first course, and laid a second, which being likewise cramped, a third course was laid: then the sluice being opened again, proper care was taken that the coffer should settle in its due place. The stone work being thus raised to within two feet of the common low-water mark, about two hours before low water the sluice was shut, and the water pumped out, so far as that the masons could lay the next course of stone, which they continued to do, till the water was risen so high as to make it unsafe to proceed any further; then they left off the work, and opened the sluice to let in the water. Thus they continued to work night and day, at low water, till they had carried their work some feet higher than the low-water mark; after this, the sides of the coffer were loosened from the bottom, which made them float, and then were carried ashore to be fixed to another bottom, in order to serve for another pier. It must be observed, that the coffer being no higher than 16 feet, which is equal to the greatest depth of water, and the foundation being 6 feet under the bed of the river, the coffer was therefore 6 feet under water when the tide was in; but being loaded with three courses of stones, and well secured with ropes fastened to the piles, it could not move from its place. By making it no higher, much labour and expense were saved; yet it answered the intent fully as well as if it had been high enough to reach above the highest flood.

The pier being thus carried on above low-water mark, the masons finished the rest of it during the intervals of the tides in the usual way; and after all the piers and abutments were finished in like manner, the arches were begun and completed as mentioned before. The whole bridge was built in about seven years, without any accidents happening either in the work, or to the workmen.

Materials employed.—All the piers were built with solid Portland stone, some of which weighed four tons. The arch stones were likewise of the same sort; but the rest of the masonry was finished with Kentish rag-stones, and the paths for foot passengers were paved with Purbec, which is the hardest stone to be had in England, except granite, called otherwise Plymouth marble.

This Method sometimes impracticable.—This method cannot be used in many cases; as where the foundation is so bad as not to be depended upon without being piled, or the depth of water is very great, with a strong current and no tide. For if piles are used, it will be impossible to cut them off in the same level five or six feet below the bed of the river; and if this is not done, the grating or bottom of the coffer will not be equally supported, whereby the foundation becomes precarious. In a great depth of water, having a strong current and no tide, the coffer must reach above the water, which makes this process expensive, unwieldy, and difficult of execution; so that there is no probability of using it in such a case.

The Russian Method.—In some cases, where there is great depth of water, and the bed of the river tolerably level, or where it can be made so by any contrivance, a strong frame of timber, four times as large as the base of the piers, may be let down with stones upon it, round the edges, to make it sink. After fixing it level, piles must be driven about it to keep it in its place, and the foundation laid in coffers as before, which are kept steady by ropes tied to the piles. This method has frequently been practised in Russia; and though the bed of the river is not solid, yet such a grating, when once settled with the weight of the pier upon it, will be as firm as if piles had been driven under the foundation; but to prevent the water from gulling under the foundation, and to secure it against all accidents, a row of dove-tail piles must be driven quite round the grating. This precaution being taken, the foundation will be as secure as any that can be made.

The French Method.—The French engineers use another method in raising the foundations of masonry under water, which is, to drive a row of piles round the intended place, nearer to, or farther from, each other, according as the water is more deep or shallow. These piles being strongly bound together in several places with horizontal tie-beams, support a row of dove-tail piles driven within them: when this is done, and all are screwed according to the nature of the situation and circumstances, the foundation is dug by a machine with scoops, invented for that purpose, until the workmen come to a solid bed of gravel or clay; or if the bed of the river is of a soft consistence to a great depth, it is dug about six feet, and a grating of timber is laid upon it, which is well screwed with piles driven into the opposite corners of each square.

When the foundation is thus prepared, the masons make a mortar called *beton*, which consists of twelve parts of pozolano or Dutch terras, six of good sand, nine of unslaked lime, thirteen of stone splinters not exceeding the bigness of an egg, and three parts of tile dust, or cinders, or else scales of forge iron: this being well worked together, must stand 24 hours, or till it becomes so hard as not to be separated without a pick-axe. This mortar being thus prepared, they throw into the coffer a bed of ruble stones, not very large, and spread them all over the bottom as nearly level as they can; they then sink a box full of this hard mortar broken into pieces, till it comes within a little of the bottom; the box is so contrived as to be overset or turned upside down at any depth; the pieces of mortar now soften, and so fill up the vacant spaces between the stones: by these means they sink as much of it as will form a bed of about 12 inches deep all over; then they throw in another bed of stone, and continue alternately to throw one of mortar and one of stone, till the work approaches the surface of the water, where it is levelled, and then the rest is finished with stones in the usual manner. A coffer containing 27 cubic feet of masonry made of this mortar, and sunk into the sea, was there left standing for two months, and when it was taken out again, it was harder than the stone itself.

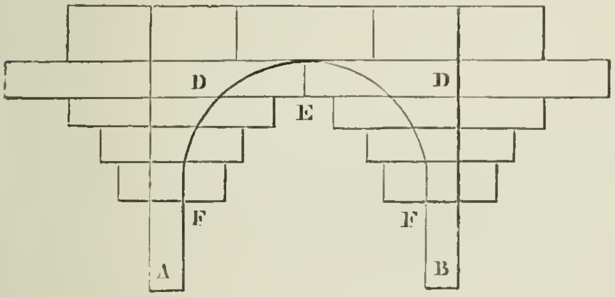
The usual way in which the foundations of Waterloo Bridge, Southwark Bridge, and Vauxhall Bridge, have been laid, was by driving piles of Memel logs, 14 or 15 inches square, for the construction of the coffer, which was cleared of water by means of pumps, and the work proceeded much in the same way as mentioned above.

GEOMETRICAL *Construction of Bridges.*—Bridges constructed with circular or elliptical arches, being the most common, we now proceed to lay down a theory for their construction, founded on philosophical principles, which, by our mode of explanation, will be understood by the mechanic, and cannot be unworthy the attention of the man of science.

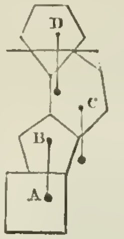
All bodies in the earth tend to the centre of the globe, unless prevented by some force that resists their obedience to the universal law of gravity, and changes their direction. If we attend particularly to one body, having all its parts tending equally to the centre of the earth, and supported in that position, it will retain its position. If we suppose another body to press upon it, so as to change that position, which it has on its support, or force away its support, in whole, or in such part, that a greater part of the body has a tendency to the centre, more than it has to its support, it will fall towards the earth in a direction to its centre.

Let A B, as in the annexed figure, be two supports, suppose one foot square, 5 feet high, or any other height, standing perpendicularly, and let a piece of the same dimensions, wood or stone, F, three feet in length, be placed across in equilibrio; the perpendicular support is not pressed by this weight, but in the perpendicular direction. If a second piece, of 5 feet, is laid upon the 3 feet piece, in the same way, projecting 1 foot on each side, they will still remain in equilibrio, and so on till the two bodies upon the two uprights meet one another, as in the figure, the planks or logs D D meet in E, without affecting the supports, except in the perpendicular direction. The equilibrium being preserved, no force imposed will make the supports give way, that will not separate the particles of matter, or break its contexture. Neither will any weight push it over, that is not greater than the perpendicular pressure; for action and reaction are equal, acting in contrary directions. The force then that it will support before it yield, is equal to the number of square feet that rests on its surface, and turns upon the angular point F. Now, suppose this operation continued the whole length of the bridge, and the whole level blocks in contact with one another, received by the abutments, or landstools, the bridge will support any weight that the strength of those blocks could sustain, and the abutments react upon. This is the genuine Egyptian arch, not elegant, but strong, as each block is supported one foot distant, and the upper ones in contact with one another, only react by their own strength, at one foot distant, without support; and by the reaction of the land abutments cannot yield to give any lateral pressure upon the pier.

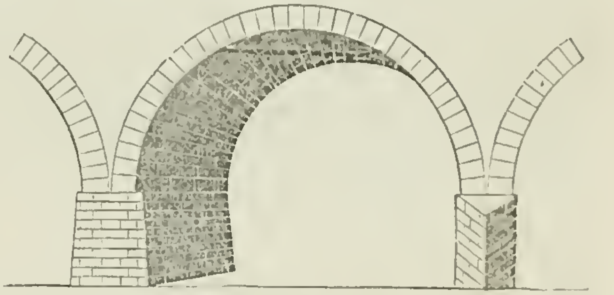
Egyptian Bridge.



Let us now suppose a semicircle of any other arch described, the superfluous matter is carried off, and the arch remains in strength and beauty. Now, instead of balancing the blocks by counterpoise on each side of the support, let this be taken off, and applied as weights above the pier, being equal in weight to those that form the arch, the equilibrium is still preserved, without any lateral pressure. This may be illustrated by a very simple experiment. Let A, B, C, D, in the annexed figure, be four blocks; the first, A, a square, which represents the base; if the second, B, a pentagon, inscribed in a circle of the same radius about which the square is described, be placed with one of its angles to the perpendicular edge of the square, a perpendicular falls within the base, and it is therefore firmly supported. Let the hexagon, C, be placed upon one of the sides of the pentagon, the two angles likewise coinciding. In this the perpendicular falls over the base; it will therefore be no longer firmly supported, but will fall, and, if attached to the pentagon, would carry a part of it along with it, except prevented by friction, and consistency of the texture of materials. In this situation let it be retained, till a pentagon is placed on the opposite side of the hexagon; the plumb line, or perpendicular, as it now appears, falls within the base, and will be again supported so as to carry an additional block raised upon it, or require a considerable force to pull it over on that side, to which the hexagon was inclined to fall. The conclusion we would draw from the above, is, that if the column or pier is of such dimensions at top, where the spring of the arch rises, that a weight of such materials as the arch is composed of can be raised, not exceeding the height of the vertex or crown of the arch, as will counterpoise that part of the arch that produces the lateral pressure; then a pier of such dimensions is of sufficient strength to support such an arch, till the other arches are thrown, and the whole made to abut upon columns that will counterpoise the whole with any incumbent weight proposed.

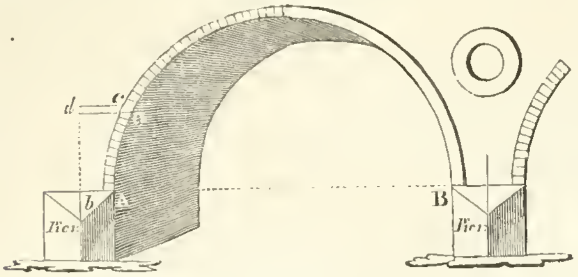


To apply the arches to their piers, and to one another, they should abut upon one another, as in the following figure.



In the next figure, we take a semicircular arch of 75 feet span, or archstone we think of a sufficient strength, at 3 feet length; our pier 6 feet, equal to the two archstones. As every arch can be raised to a certain height, without the support of the centre arch; allowed, to the 30th degree, or one-third of the distance to the crown of the arch, we have divided the quadrant or half of the arch into eighty-three equal parts; and where more than half of the archstone falls over the perpendicular, we consider this as the height, not to be exceeded without support. The weight of matter upon the pier to this height, we compare with the weight of matter from that contained in the archstones, or rather, what breadth of pier will contain a quantity of matter that will counterpoise the weight of the archstones of an arch of given span, and length of archstones to the crown of the arch. In investigations of this kind, recourse is had to trigonometrical calculations, and to algebraic and fluxionary equations. Foreign writers give us rules, collected from such constructions as suited their taste; and most algebraic and fluxionary equations take their data from some bridge, the construction of which pleases the writer, and brings his result agreeable thereto.

Let us consider the archstones as wedges abutting upon one another, and the whole upon the landstool, or upon the pier of the particular arch, and resisted by pressure, which may be expressed by a line placed at right angles to an archstone, at that part of the arch which rests upon the centre arch; but whose length is not yet determined, but will be determined in the result of our theory, of which every mechanic is able to judge; and which, at the same time, we flatter ourselves the learned will not find cause to challenge.

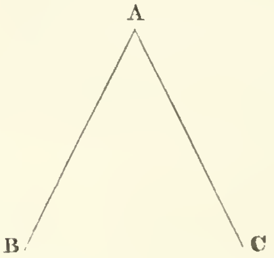


The thickness of the pier we have taken is, A *b*, 6 feet; each division of the arch is equal to 2 feet on the outside, and tends as a wedge to the centre of the circle. The inside measures 1·8 feet, the mean is 1·9 × 3; the length of the stone is 5·7 of surface: we suppose it taken 3 feet into the arch, or it is equal to 17·1 solid feet in each of our divisions; the scale is half an inch to 10 feet. The solid measure on the whole is easily found; the 30° is at *a*, but the arch will rise without the support of the centre arch to *c*. Now, the number of divisions from *a* to the centre of the arch, is 22·2; which multiplied by 17·1 solid feet each, is 379·62 solid feet; the pier of 6 feet contains to the height, *a*. the surface *A b d a*, at a mean, taken as in the table, *a* is 72·75, being each 2 feet, is 145·5 superficial feet, × 3, the assumed depth is 436·5 solid feet, being fully in equilibrium with the archstones; but as the arch will rise to *c*, there is an additional weight of 229·5 solid feet, which will be allowed more than a counterpoise to the pressure of the arch, without any aid from the pier, which has only the perpendicular pressure to support. By this, therefore, is ascertained, the counterpoise which will support this arch until the other arches are raised; which, as they all abut upon one another, the landstool must be made of such strength as to counterpoise the whole. This is ascertained upon the same principle, and leaves no stress upon the piers, but the perpendicular pressure alone. This pier is scarce one-twelfth part of the opening, by which, the river having so free a passage, will affect the bridge by pressure but very little. The above figure is a perspective view of one arch of a bridge, on this construction, with part of an adjoining arch on each side.

But the piers must be made of greater breadth, when the situation of the river, or other circumstances, or when a segment of a circle is made choice of for the ease of the passage, or when economy in the use of materials and mason-work are considered; or the base of the arch, or the surface of the pier, will not admit of mason-work to bear upon the spring of the arch, of such weight as to produce a sufficient counterpoise to the archstones that produce the lateral pressure. If the arch is flatter than that now under consideration, the pier ought to be broader; and this is ascertained in projecting the plan. At the same time, as the fall and destruction of an arch is attended with very great loss in money, time, and materials, by way of precaution, beams may be made to abut upon one another, and upon each pier; and this will be no loss of time or materials either, as it will supply, in part, the support of the centre arches, upon which the arch of the bridge is raised; and it is a precaution used, upon a smaller scale, when, in front walls of houses, the whole is often supported upon arcades of shop doors and windows, many of their piers not exceeding 9 or 10 inches: a cross bar, or piece of wood laid across, to prevent their yielding or losing the perpendicular, till the whole is completed. Now, the pressure upon the arch is not so great as most writers have assigned, that is, to the whole incumbent weight of all the materials above it, together with that of passage. The art of masonry is such, that the beds or rows of stones are so bound one with another, that each makes a pressure on its contiguous part, so as to form an arch of themselves. We see in well-built walls a vast excavation made in the lower part, or in the middle of the wall, and the upper part of the building not affected. In like manner, the arches being all raised to the height that they can be, without the support of the centre arch, they are completed and filled up to the level of the keystone, but not higher. The arch is properly secured, if the principles of equilibration, in filling up, are properly attended to; but if one side is overloaded, either in filling up or in building, it must twist the arch, and, if not instantly to break it, must tend to an uncertainty as to its durability.

Among the various writers upon bridges, some prefer the circular arch, both for strength and elegance. Others contend, that it is exceeded in both by the elliptic arch. Others will give the preference to the catenarian arch; and we are told, that the excellency lies on the side of the parabolic curve. We do not think it incumbent on us to combat each of these; neither do we think our readers would thank us for so doing. It may, however, be expected, that we should not pass them entirely unnoticed.

In the first place, then, we are of opinion, that the arch that bears most equally throughout the whole, one part upon another, has the best claim to strength. Our reason is, which we illustrate thus, let A B, A C, be placed as in the annexed figure. Suppose a weight, placed upon them in such a manner as to press equally upon the point A, the two bodies A B, A C, will in that point support the greatest weight. If the same weight is laid in the middle, between A and C, or A and B, they will each yield to the pressure; for the weight is not equally divided between them. But if these bodies are so placed, that in every position on which a weight can be applied to them, the weight shall be equally supported by both, we should give this form the preference as to strength; and this is the case with the circle. As to elegance, we know that regularity is a qualification that suits every taste; and here the circle cannot be outvied. It is not, however, without its disadvantages; for with regard to expediency, the semicircular arch is sometimes too high for the situation of some bridges. In this case, the elliptic arch, formed upon the greater axis, offers itself, in point of expediency, and yields not in point of elegance. We are bold enough to assert, that if strength of materials forms its composition, and be properly abutted, it will not yield, in point of strength, in any exigence to which it may be applied. In point of economy, it claims a preference to the semicircular arch.

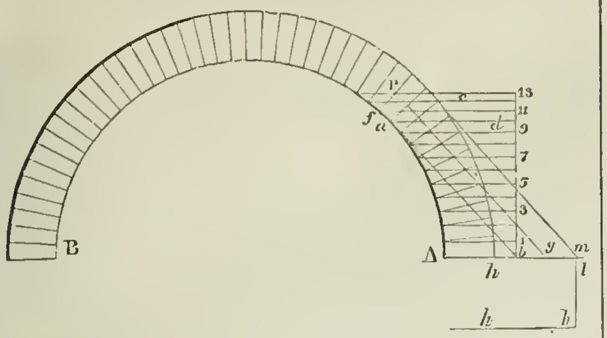


For our part, we are inclined to own the reasonableness of its claim, and to give it the preference to the segment of a circle, which might perhaps be preferred in point of expediency, as it can be rendered as flat as the ellipse; but its flatness we rather consider as a disadvantage, as in the rise of the water it is apt to choke its course, and overturn it; whereas, the ellipse being nearly formed of two segments of circles of different radii, the smaller arches at its extremity raise more in the perpendicular, and give more scope to the current of the water; and likewise, it does not require a stronger pier than a semicircle of the same diameter. The segment, on the other hand, if flat, requires a stronger pier, and therefore tends more to choke the current of the river, which ought always to be avoided when it can be done.

In the catenarian arch, when a chain or rope is fixed at each end, and allowed to fall down in the middle, the curvature is not equal throughout; and we therefore cannot think it entitled to equal claim with the circle or ellipse. The same objection may, with equal propriety, be made to the parabola. This curve, near its vertex, has almost the property of a circle; but every one who knows a parabola, is convinced how much it deviates from it afterwards, although every where it retains the property of its own curve.

We now take a review of the different bridges we have mentioned, and make some observations upon them. In general, we remark, that all the writers upon this art have formed the abutments of each particular arch, to be placed in the pier below the spring of the arch; on which account, many have constructed their piers of greater strength than necessary; as in that by the Roman emperor Trajan, over the Danube; but being broken down by his successor, to impede the passage of his invaders, we cannot, with certainty, compute the lateral pressure upon the piers.

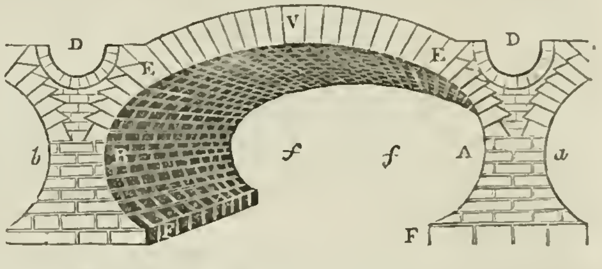
According to the rules given by Belidor, the breadth of the pier that will form an abutment to an arch of 75 feet span, is 14 feet, if the height at the head of the columns be 6 feet. We have formerly stated, that this arch can be raised to *c*, as in the following figure, without applying the centre arch. From the centre of this archstone we raised a perpendicular *p g*, and from the lower part of the archstone drew the line *f b* parallel to it: this line, *f b*, we supposed to cut the centre of the pier in *h*. Suppose Belidor allowed a part of the pier equal to the length of the archstone, which we have in this figure taken at 3 feet, one-twenty-fourth of the opening nearly, *viz. h b*, A *h*, would be allowed for the perpendicular support of the archstones to *c*. We find *h g* measures five and a half feet, we therefore extend *h g* to *l*, which is 11 feet, and A *l* 14 feet, for the breadth of the piers. In place of taking the whole width of the bridge, we take only 3 feet, as formerly. The number of equal divisions from *c* to the vertex, or middle of the keystone, is 20½; each of the equal divisions at these breadths contains 17·1 solid feet; as by our former measure, which multiplied by 20½, is 350·55 solid feet. The pier, 14 feet broad by 6 in height, and 3 feet deep, is 252 solid feet: the solid building, *c f b m*, being supported in the perpendicular, he considers as a part of his abutment, of which *f b* measures 26 feet, by *c f* 3, and by 3 in depth, is 234 + 252 = 486 solid feet, to counterpoise 350·55 solid feet, which is amply sufficient. Suppose that the pier is 13 feet, at the above height it contains 234 feet, + 234 as before, = 468 feet, which, to account for accidents, and from his practice and observation, gives the dimensions of the table rule, which, we suppose, is now fully accounted for. If the height of the pier is more than 6 feet, we add to the breadth of his pier in proportion. When the span is above 80 feet, one-sixth of the opening is sufficient in strength to resist every exigence; but if the arch is a segment, the same rule gives the breadth of the pier rather more than 14 feet. Belidor confines his rule to the semicircular arches. We have already mentioned what we think a proper limitation to his rule for taking the 24th part of the arch for the length of his archstone.



London Old Bridge, executed in stone, under the direction of Peter Colechurch, a priest; was thirty-three years in building, being begun by Henry II. in 1176, and finished by John in 1209. The piers, eighteen in number, are from 25 to 34 feet thick. Peter turned the course of the Thames through Southwark, while he executed an undertaking that choked up the course of the river, from 900 to 194 feet; but as this objection is about to be removed, we need say no more about it.

Westminster Bridge, an elegant and noble fabric, has its pier only 8 feet from the bed of the river. The thickness, for a sufficient counterpoise to the arch, could not exceed 14 feet; but lately, the architect has given it 17. The arches are semicircular, the middle one being 76 feet span; the ascent one-twentieth part of the half-width of the river, which is here 1223 feet, one half is 621·15, and the rise is 30½ feet in that extent.

The next we notice, is Blackfriar's, as in the following figure, executed by Mylne, whose ingenuity and ability as an engineer are universally acknowledged. The middle arch is an elliptic span of 100 feet, by which, with other advantages, the passage is rendered more commodious; the ascent more easy than on Westminster Bridge. The quickness of the rise of the arches of the small circles, with the flatness of the large circle, are particularly well adapted to give a more easy passage to the river, when rising either from a tide or other accidental causes, and renders the choice of the elliptic arch here very judicious. We are likewise much pleased with the ingenuity of the inverted arch, which effectually prevents any rising of the ruble work that fills the interstices between the arches by any pressure whatever; as it abuts upon the archstones at E, it presses their joints upon one another, in a more effectual manner than perhaps could be accomplished by any other method; but the effect produced by it, and in which we think its excellency mostly consists, is, that it makes the arches, at that point where they produce the greatest lateral pressure, to abut upon one another, and thus take off the lateral pressure from the pier. Had Mylne availed himself of this, his pier would have been at least one half thinner. But in place of this, he has made it at the extremity of the greater axis, A *a*, B *b*, 19 feet, and increased it in a circular form to 22 feet. Experience has proved, that when the resisting force is placed in the pier, one-fifth of the opening is more than sufficient for supporting this resisting force; therefore the course of the river should not have been contracted from 100 to 70 feet.



The depth of the water, at ordinary tides, is not less than 16 feet; and by the principles of hydrostatics, the pressing force of a solid foot of water, at that depth, is equal to 8500 lbs. which × 30, the number of feet contracted, gives 113·8 tons upon the foundation of his pier, far more than was necessary; but this does not at all derogate from the method.

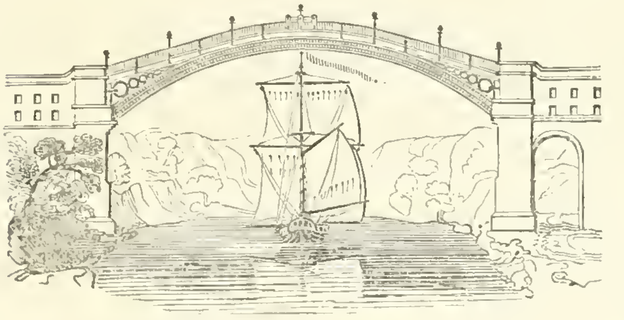
In our drawing of the middle arch, and part of the adjoining arches, A B is the length of the greater axis of the ellipse, and span of the arch 100 feet; *f*, *f*, the centres of the lesser circles; D D, the inverted arches abutting upon the archstones E E; V, the vertex or crown of the arch; F F, the thickness of the pier at the bed of the river; A *a*, B *b*, the thickness of the pier at the extremity of the greater axis. We have put on the bolting in one of the arches, one with the Kentish rag-stone; the bolts about a cubical foot, sunk half way into each stone; the stones in the pier are bolted with firm oak, of a solid foot, dove-tailed into each stone, which renders the whole pier firm as if one stone.

What has been said on the breadth of piers, renders any observations on the bridge over the Trent at Burton, or the single arch over the Tave, in Glamorganshire, unnecessary; the abutments of the last being on land, the method of obtaining their strength will be pointed out when we speak of the abutments of iron bridges, of which there are now several in England.

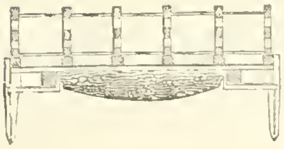
The first was that erected over the Severn, near Coalbrookdale, in Shropshire, by Abraham Darley; the iron work was cast at Coalbrookdale in 1779, and consists of one arch of 100 feet 6 inches span. It rises to the height of 45 feet, and consists of ribs, each cast in two pieces, secured at the crown by a cast iron keyplate, and connected horizontally and vertically by cast iron braces formed with dove-tails and forelocks; the ribs are covered with cast iron plates; the railing is of iron: the weight of the whole is $387\frac{1}{2}$ tons. The ironwork was executed by Messrs. Wilkinson and Darley, ironmasters; for which they have great credit, being the first instance of that material applied in the bridge way. In 1801 it appeared as perfect as when put up, except what was owing to the failure in the stone abutments, which had occasioned some cracks in some of the small pieces.

The second bridge of this kind, built over the same river at Builtwas, at the expense of the county of Salop, was agreeably to a plan under the direction of Mr. Telford, surveyor of the public works in that county: the iron work was cast at Coalbrookdale in 1795 and 1796. It consists of an arch of 130 feet span; the rise of the arch is 27 feet from the spring to the suffit. The situation of the road here is necessary to be kept low; and the outside ribs rise as high as the tops of the railing, and are connected with the ribs that bear the covering plates, by bars of iron cast with deep stanches close to each other, and forming an arch of themselves; so that the bridge is made, upon the whole, compact and firm: the weight of the whole is 173 tons $18\frac{1}{2}$ cwt. Some smaller arches, and an aqueduct at Longdon, have been made under Mr. Telford's direction in the same county.

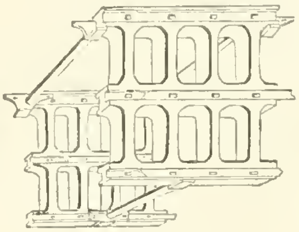
The next, upon a large scale, and made of iron, is that over the river Wear, at Monk-Wearmouth, in the county of Durham. This bridge, as represented in the following figure, is the segment of a circle, whose radius is 443 or 444 feet; the span of the arch, or length of the bridge, is 236 feet; the height of its vertex above the spring of the arch is 34 feet; and height above the surface of the water 60 feet; so that vessels of considerable burden may pass below it without interruption. The width of the bridge, or breadth of the roadway, is 32 feet: it is formed of six ribs, placed above five feet distant from one another; each rib consists of 125 blocks of cast iron, five feet in height, and two feet broad at the middle. The lines drawn from this to the centre of the curvature, determine the length of the block above and below; and a circle described with the radius of curvature, gives the convexity of the upper part of the block, and the concavity in the lower, agreeable to the curvature of the whole arch of the bridge.



Section of the Bridge.



Frame of one of the Ribs.



In each of the three longitudinary parts of the block, there is a square groove one inch deep, into which is fitted a bar of wrought iron of the same dimension with the groove; and by this means the blocks are joined together to form the ribs These ribs are connected laterally by a hollow bar of cast iron, about 4 inches diameter, and 5 feet long, with flanches through which iron bolts are made to pass it, and the sides of the ribs fixed with screws or forelocks; two of the blocks are joined by the bars of wrought iron, and connected with a bar of another rib, by the iron hollow bar. All the ribs joined together, and connected in the same manner, to complete the arch of the bridge. To support the beams that form the roadway, circular pieces are formed of cast iron, to abut upon one another at their horizontal diameter, the beams that form the roadway resting upon the circular pieces at the vertical diameter, which gives a firmness to these supports, that no weight coming upon the bridge can injure. The beams or planks are then covered with plates of iron, and such materials as are best adapted to form the road, and prevent water passing through to injure the bridge.

We have only to add, that this bridge was constructed under the direction, and chiefly at the expense, of Rowland Burdon, Esq. then M. P. for the county. It was cast at the foundry of Messrs. Walker, of Rotherham, in Yorkshire, and does honour to the projector and ironmasters. It is nearly double the span of that at Builtwas, and more than double the middle arch of Blackfriar's Bridge.

Our only doubt of the durability of iron bridges is, that the water, being blown in by storms, rests on the flats of the iron, and tends to corrode it, and waste its parts. The union of cast and wrought iron certainly produces a larger quantity of oxide or rust, than if all is cast, or all wrought iron. Perhaps, if between these thin plates of lead were placed, the two pieces might have their joints closed, by abutting upon the lead, and the same precaution being taken with the wrought iron, where inserted into the grooves of the cast metal, the water would be prevented from entering, or settling in the interstice.

Bangor Ferry Iron Hanging Bridge. (See Plate, fig. 1.)—The iron hanging bridge, constructed over the Menai Strait, by Mr. Telford, consists of one opening of 560 feet between the points of suspension, and 100 feet in height between the high-water line and the lower side of the roadway; and the roadway being horizontal, this height is uninterrupted for the whole 560 feet, except where the natural rock, which forms the western abutment, now interposes. But in addition to these 560 feet, there are four arches on the western and three on the eastern side of the main opening, each fifty feet span, making in all 850 feet, as in the plate, fig. 2.

In regard to the navigation, it is preferable to any bridge of an arched form, because the latter affords the full height of 100 feet only in the middle; whereas the former affords the same full height for the whole of 500 feet, which is a considerable advantage to vessels passing the Menai Strait, as it allows them to stand closer to either shore while passing under the bridge. In regard to economy, this bridge, on the principle of suspension, has equally the advantage, the estimated expense not being more than £70,000: whereas the cheapest of the arched form, made of cost iron, would have cast nearly double that sum.

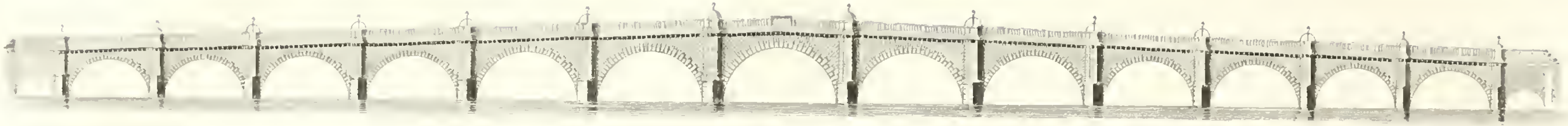
The roadway (Plate, fig. 3,) consists of two carriageways, each 12 feet in breadth, with a footpath of 4 feet between them, so that the platform will be about 30 feet in breadth. The whole is to be suspended from four lines of strong iron cables by perpendicular iron rods, placed 5 feet apart, and these rods will support the roadway framing. The suspending power is calculated at 2016 tons, and the weight to be suspended, exclusive of the cables, is 342 tons, leaving a disposable power of 1674 tons. The four sides of the roadways, made of framed ironwork, are firmly bound together for 7 feet in height, and there will be similar work, for 5 feet in depth below the cables. The weight of the whole bridge, between the points of suspension, is 489 tons.

It is calculated that the contraction and expansion of the iron cables may occasion a rise or fall to the extent of four or five inches; but the variations of the temperature of the atmosphere will not derange the bridge.

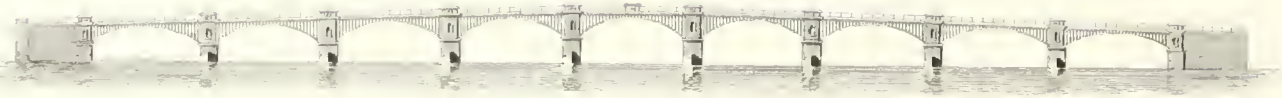
The two piers are 60 feet by 42 and a half wide, at high-water mark, having a foundation of rock. These piers, connected with the whole of the masonry, form a mass constructed

BRIDGES.

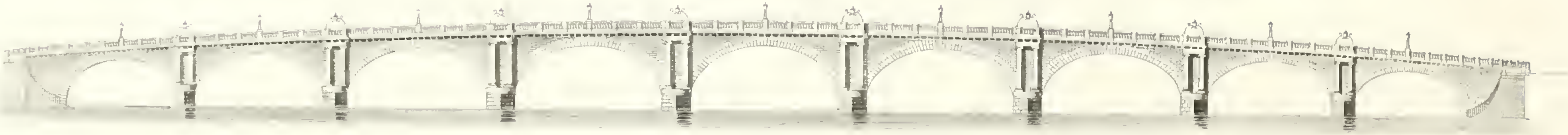
Westminster Bridge



Vauxhall Bridge

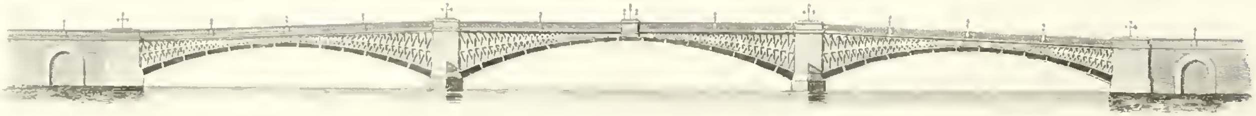


Blackfriars Bridge

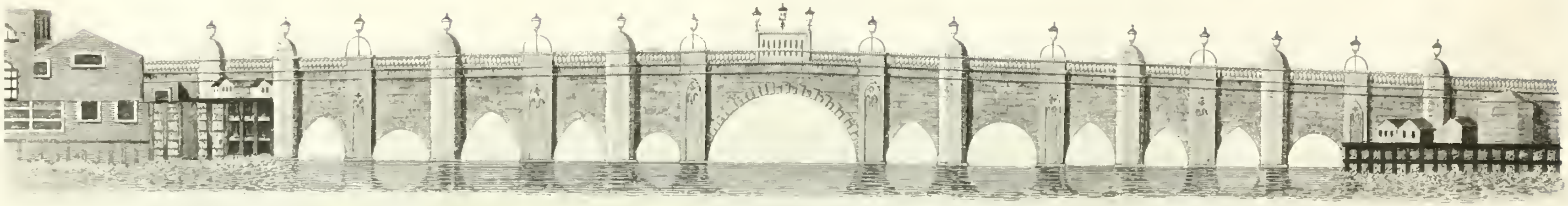


Waterloo Bridge

Southwark Bridge



London Bridge



[illegible] by H Fisher [illegible]

with blocks of hard limestone, of much greater weight than is necessary for supporting a bridge of this kind. Upon the summit of the two main piers is erected a frame of cast iron, of a pyramidal form, for the purpose of raising the cables from which the bridge is suspended. As the cables are carried from the top of the pyramids, so as to form nearly similar angles on each side, the pressure is almost perpendicular.

Along each line there are four cables, making in the whole sixteen; these cables pass over rollers fixed on the summits of the pyramids, and are fastened at their extremities to an iron frame, lying horizontally over the top of the small arches, and under a mass of masonry.

From these cables the roadway is suspended by vertical iron rods, connected at their lower extremities with wrought-iron bars, both transversely and longitudinally, thus forming a frame on which timber is laid for the roadway. The distance of five feet is kept between the rods, that the suspending power may be equally distributed throughout the whole length of the bridge. The suspending rods pass between the cables, and depend upon each two of them, so that the general strength of the bridge could not materially be affected by taking one way. The cables and the flooring, as well as the suspending rods, are constructed and united in such a manner, that each of the parts may be taken out and replaced separately; so that there can be no difficulty in repairing any part of the bridge, whenever required. A temporary wire-bridge was made from one abutment to the other, to carry over the cables, and arrange the several parts of the bridge, while building.

The weight of each separate cable between the points of suspension is estimated at nine tons and three-quarters, or 117 pounds per yard. The weight of a drove of oxen is calculated at about 300 tons, supposing them to amount to 200 head, all closely huddled together; and the estimated weight necessary to tear the cables asunder is upwards of 2000 tons, which is about four times the weight of the entire bridge. The passing of a mail-coach over the bridge produces no undulation, or sensible perpendicular vibration; nor is any lateral vibration apprehended from the most violent gale of wind, by reason of the proportion that the breadth of the bridge bears as a frame to its extreme length. The bars, as well as the segments, are each joined longitudinally to the whole of the required length, and secured by bucklings every five feet, and then enveloped in flannel, well saturated with a composition of rosin and bees-wax, to preserve them from the weather, and the whole are encircled with iron wire.—All these details will be clearly understood by reference to the engraving that exhibits the passage upon the bridge.

The Strand or *Waterloo Bridge.* (See Plate, *Bridges.*)—This bridge, which is now called "Waterloo Bridge," but which was, till within some few months of its completion, styled "the Strand Bridge," is a noble ornament of the metropolis. The view of the Surrey hills, and the fine expanse of country that it opens from the Strand, is both delightful and surprising; and the effect is not a little increased by the continuity of houses that every where affects the passenger's eye, in passing along the Strand, till he comes to the grand entrance, leading to Waterloo Bridge. For upwards of a century, a bridge at this particular part of the river had been frequently suggested; but all the merit of the scheme, and the influence of the Bedford family, whose property would be so much improved by the adoption of the plan, did not enable it to resist opposition from the city of London, &c. in former periods. It remained for George Dodd, an enterprising and young civil engineer, after three years' unprecedented turmoil, to get an act of parliament for a bridge at this station; and this was not done till subscriptions to the amount of £500,000 had been raised. This was in 1806. Mr. Dodd succeeded in removing the impracticabilities, which had before prevented the scheme of building a bridge across this portion of the river from being carried into effect; and he gave the present plan and dimensions of the bridge.

Some time after the act had been obtained, and the commencement of the building, Mr. Dodd disagreed with the company, and separated from them, and the late Mr. Rennie followed; and he had the honour of finishing this noble bridge, which is different from all the other bridges. All its arches, which are elliptical, are of an equal size; and the road across the bridge is thus made a level road. The style of its architecture is plain; the effect noble, from its simple grandeur; and the materials are of the most durable kind, namely, of granite. It was built with amazing rapidity, and the ceremony of opening it took place June 18, 1817, the anniversary of the battle of Waterloo. The ceremony was of a splendid character, the Prince Regent and the Duke of Wellington being present on the occasion.

The following are the dimensions of the bridge:—

The length of the stone bridge within the abutments,	1242 *ft.*
Length of the road supported on brick arches on the Surrey side of the river,	1250
Length of the road supported on brick arches on the London side,	400
Total length from the Strand, where the building begins, to the spot in Lambeth, where it falls to the level of the road,	2890
Width of the bridge within the balustrades,	42
Width of the pavement or footway on each side,	7
Width of road for horses and carriages,	28
Span of each arch,	120
Thickness of each pier,	20
Clear waterway under the nine arches, which are equal,	1080
Number of brick arches on the Surrey side,	40

The whole of the outside courses of the bridge is Cornish granite, except the balustrades, which are of Aberdeen granite; and the stones, like those of the Temple of Solomon, were cut to their respective forms at the quarries, before they were brought to London.

There are 320 piles driven into the bed of the river under each pier. The length of each pile is from 19 to 22 feet, and the diameter about 13 inches. There is one pile to every yard square.

The scientific manner in which the centres were constructed was admirable; and as all the arches are of the same size, the centres were removed from those that were finished, and placed on the piers where the arches were not yet thrown: this was an operation that required great skill and care, and was very ably executed.

When the centres were removed, so solidly and well was the masonry constructed, that in the middle they only sunk about one inch. Those of the Pont de Neuilly, in France, six miles from Paris, which are nearly similar, sunk about 18 inches in the middle, after the centres were taken away. The scientific principle on which the centres were constructed, which did great credit to Mr. Rennie the engineer, was that of the *longitudinal incompressibility of timber.* The strongest and largest beams of wood bend and yield when pressed upon laterally; and by that means the form of a centre, constructed in the usual manner, is different when loaded, from what it is when not loaded; but as no weight that men are acquainted with, when acting gradually, will shorten the length of a beam, it was so contrived that the pressure acted always longitudinally or lengthwise, and not laterally or sidewise; so that those centres remained in form unchangeable, as much as if they had only one solid mass of matter, the two extreme points resting on the firm and well-constructed piers.

In circular arches, such as those of Westminster, or other bridges, the pressure on the centres, before the keystones are put in their place, is not near so good as in elliptical arches, like those of Waterloo.

The four toll-lodges are neat appropriate Doric structures. There is a clever contrivance at each lodge, for the purpose of checking. The kind of iron turnstiles, which admit of only one person passing at a time, touch some machinery which communicates with a clock, locked up in a box in each toll-house, the index of which is thereby moved, so that on looking at it, the number of those who have passed is directly seen.

The bridge was only six years in building. It is exactly on a level with the Strand, where it joins, and is 50 feet above the surface of the water of the river Thames.

The first stone of the bridge was laid on Friday, the 11th of October, 1811, by Mr. Henry Swann; a bottle containing coins of his late Majesty's reign, was deposited in the first stone, over which a plate with the following inscription was laid:—

"This foundation of the Strand Bridge was laid on the 11th day of October, A. D. 1811, by the Directors for executing the same, Henry Swann, Esq. M.P. chairman, in the 51st year of the reign of King George the Third, and during the regency of his R. H. George Prince of Wales. The money for building which was raised by subscription, under the authority of an Act of Parliament. *Engineer*, JOHN RENNIE, F.R.S."

Vauxhall Bridge. (See Plate, *Bridges.*)—This bridge was originally projected by Ralph Dodd, the father of the engineer above alluded to; but with the actual building of this bridge, Ralph Dodd had little or nothing to do. See *Leigh's Picture of London.*

Some subscriptions were received, and the building of a bridge on the present site of Vauxhall bridge was determined on; but in the co-operation of this, Mr. Dodd was, on account of some disagreements, dispensed with. Mr. Rennie, the Waterloo-bridge engineer, followed. An immense quantity of good stone was brought; laborious efforts were made to build the piers, &c.; but thousands of pounds were expended to no purpose. The completion of the bridge was interrupted till Mr. Walker was engaged; and the result was, the building of the present elegant iron bridge. The whole expense of building was within £150,000: and much more is said to have been previously expended in vain.

The first stone of this bridge was laid in the year 1813, by Prince Charles, the eldest son of the late Duke of Brunswick; and the present beautiful erection was completed in 1816. It consists of nine cast-iron arches, with piers formed by a wooden frame as a foundation, faced with Kentish rag-stone and Roman cement.

Southwark Bridge. (See Plate, *Bridges.*)—The plan of this bridge was originally proposed and brought forward by Mr. John Wyat, with the view of forming a communication between Bankside, Southwark, and the bottom of Queen-street, Cheapside. The celebrated Rennie has the merit of the design. It consists of three arches only, of cast iron, from the foundry of Messrs. Joshua Walker and Co. of Rotherham, in Yorkshire, on massy stone piers and abutments.

This is a most stupendous iron bridge; and, so far as respects its centre arch, is of greater span than any other in the world. It was opened in April, 1819. Doubts having existed with the unscientific part of the public, as to the practicability of this Herculean structure, whether it could, in its colossal strides, span the frontiers of old father Thames, the following curious and interesting particulars cannot fail to be acceptable.

This work was begun on the 23d September, 1814, under the direction of Mr. Rennie as engineer, and Mr. Weston, sub-engineer. Messrs. Jolliffe and Banks were the contractors at a lump or specific sum, and, what is rather a novelty in public works of this vast magnitude, it was completed within the contract price. The estimated expense of the bridge amounted to £287,000.

The distance between the abutments is 708 feet. The extent of each abutment enclosed, including the land arch and invert arch, is 71 feet, formed of solid masonry; all the springing stones of which weigh 13 tons each, and are of granite, similar to the other parts of the bridge stone work. There are two piers, 60 feet high each from the bed of the river to the top of the parapet, and 24 feet in breadth between high and low water marks, and 75 feet long between acme and acme of the salient angles. The foundations of the piers are each about 12 feet below the bed or bottom of the river, and rest on a platform of 2½ feet thick of solidly compacted timber; and these platforms each further repose on about 420 piles, most of which are driven 24 feet into the earth, making the depth of the earth, from the shoe of the piles to the parapet top of the piers, 98 feet. There are three arches of iron; the two side ones are 210 feet each in span, and the centre arch is 240 feet in span, with 43 feet clear opening above low-water mark, medium tides. Thus it exceeds the admired bridge of Sunderland by 4 feet in the span, and the long-famed Rialto at Venice, by 167 feet. Many of the iron single or solid castings weigh 10 tons each: and the total weight of iron exceeds 5308 tons.

The centerings of this bridge on which the arches were formed or turned, were of such a novel and peculiar construction, that the navigation of the Thames was comparatively unimpeded during the building of the bridge. The entire centering of one arch, containing 480 loads of timber, was removed into two tides, having been previously and gradually sunk by loosening of the wedges; unlike the Pont Neuilly, from which the centerings were all struck simultaneously, or rather thrown into the river Seine, and in which the arches settled the surprising depth of 18 inches almost instantly. It was calculated, and allowed, that the centre arch of Southwark bridge would settle at the vertex two inches, yet it has only settled or sunk 1⅞ inch precisely; thus the wide expanse is within one-eighth of an inch of the figure and form it was originally designed to assume.

The following is a specification of the lengths of the several bridges:

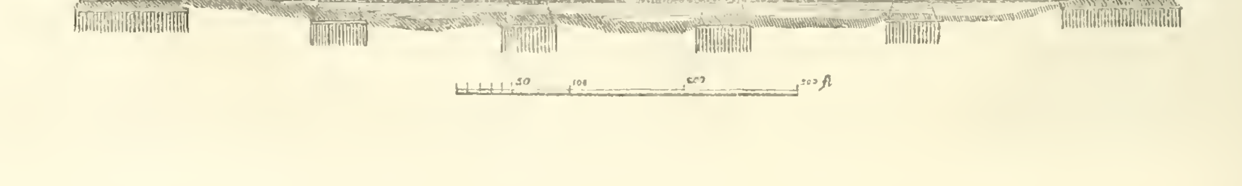
	Feet.
Waterloo Bridge, within the abutments, ...	1242
Westminster Bridge, from wharf to wharf, ...	1223
Blackfriars' Bridge, ...	940
London Bridge, ...	900
Vauxhall cast-iron Bridge, ...	860
Southwark cast-iron Bridge, between the abutments,	708

New London Bridge.—This work was commenced on the 6th March, 1824, under the direction of Mr. John Rennie; second son of the late celebrated engineer (whose stupendous works reflect so much honour on himself and country,) assisted by Mr. James Hollinsworth and Mr. Knight. The bridge is to consist of five beautiful semi-elliptical arches, the centre one of which will be 150 feet span, the adjoining 140 feet, and the land arches 130 feet. They are now constructing of the most durable granite from Aberdeen, Devonshire, and Cornwall, and may be justly considered the boldest of their kind in Europe.

The contractors for this stupendous undertaking are the same who have carried into effect so satisfactorily the other two works of a similar nature, viz. Waterloo and Southwark bridges, (Messrs. Jolliffe and Banks.) And from the sound and scientific manner in which the work under remark is proceeding, there is every reason to believe that they will speedily complete it to general satisfaction.—Their contract for the new bridge, and some alterations in widening the water-way of the old one, is £506,000, and they are bound down in heavy sureties to complete it in March, 1830.

Original contract, ...	£426,000
Additional width, ...	42,000
Fourth, sets of centres, ...	8,000
Alteration, of the old bridge, ...	30,000
Total,	506,000

It is understood that the removal of the old structure will be a separate contract.



BRIGGS, Henry, is well known as the improver of Napier's logarithms. This great man was born at Warley Wood, Halifax, Yorkshire, in 1556, and died at Oxford in 1630. He preferred retirement to the splendours of life, and humble probity to the accumulation of vast riches, which his abilities might have procured.

BROKEN-BACKED, the state of a ship, so loosened in her frame, either by age, weakness, or some great strain, as to droop at each end. This circumstance is more common among the French than the English or Dutch ships, owing partly to their great length, and to the sharpness of their floor, whose breadth is not sufficiently carried from the middle towards each end, and partly from being frequently obliged to have a great weight on both ends, when they are empty in the middle, at the time of discharging one cargo and taking in another.

BULK-HEADS, partitions built up in several parts of a ship, to form and separate the various apartments; some of which are particularly strong. Others are light, and removable at pleasure, to clear the ship for action. The bulk-head afore, is the partition between the forecastle and the gratings in the head, and in which are the chase ports.

BULL'S EYE, a piece of wood in the form of a ring, which answers the purpose of an iron thimble: it is seldom used by the English seamen, and then only for the main and fore bowline bridles.

BUMBOAT, a small boat, employed to carry vegetables, &c. for sale, to ships lying at a distance from the shore.

BUMKIN, or Boomkin, a short boom, or beam of timber, projecting from each bow of a ship, to extend the clue or lower corner of the foresail to windward: for which purpose there is a large block fixed on its outer end, through which the tack is passed, which being drawn tight down, the tack is said to be aboard.

BUNT-LINES, ropes fastened to cringles on the bottoms ot the square sails, to draw them up to their yards: they are inserted through certain blocks above, or on the upper part of the yard, whence passing downwards on the forepart of the sail, they are fastened below to the lower edge, in several places of the bolt rope.

Bunt-Line Cloth, the lining sewed up the sail in the direction of the bunt-line, to prevent that rope from chafing the sail.

BUOY, a sort of close cask, or block of wood, fastened by a rope to the anchor, to point out its situation. Buoys are of various kinds, as, *Can Buoys*, which are in the form of a cone. Of this kind are the buoys which are floated over sands, &c. as marks for ships to avoid them: they are made very large, that they may be seen at a distance; where there are several near each other, they are distinguished by the colour, as black, red, and white. *Nun Buoys*, are large in the middle, and taper nearly to a point at each end. *Wooden Buoys*, are solid pieces of light timber, having one or two holes through the ends, in which is fixed a ring of rope called the strop.

Cable Buoys are common casks, employed to buoy up the cables in rocky anchorage, to prevent their rubbing against the rocks. In the harbour of Alexandria in Egypt, every ship is moored with at least three cables, and has three or four of these buoys on each cable for this purpose.

Life Buoy is generally of the Can kind, though sometimes it is made of cork. It is furnished with a small flag on the top, and is used to throw overboard for a person who has fallen into the sea to lay hold of; while the flag serves to direct a boat to the spot, and thereby frequently saves the life of a fellow creature.

Buoy *Rope*, the rope which fastens the buoy to the anchor, and should be always of sufficient strength to draw up the anchor; it should also be little more in length than equal to the depth of the water where the anchor lies.

BURNING, the action of fire on bodies, whereby the minute parts of them are separated, and thrown into violent motion, some of them assuming the nature of fire themselves, fly off *in orbem*, while the rest are dissipated in form of vapour, or reduced to ashes.

Burning *Glass*, a convex lens which transmits the rays of light, but in their passage refract or incline them towards a common point in the axis called the focus; and by thus combining together in a single point the power of all the rays transmitted through the glass, a very great degree of heat is accumulated in that point, which will fuse bodies that are infusible in the greatest culinary heat that can be produced.

Burning *Mirrors*, or *Specula*, are concave reflecting surfaces, commonly of metal, which reflect the rays of light falling upon them, but at the same time incline them towards a determined point or focus, where their accumulated effect operates in the most powerful manner, burning and dissipating the hardest and most infusible bodies.

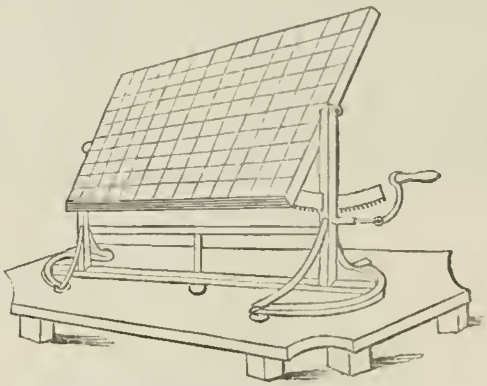
Those burning glasses which consist of refracting convex lenses, though not entirely unknown, were very imperfectly understood by the ancients; but the latter kind, the burning mirrors, they seem to have had in greater perfection than the moderns, at least if we may credit the relations of several eminent historians, who assert that Archimedes, by means of such mirrors, burned and destroyed the Roman fleet, which, under Marcellus, was employed at the siege of Syracuse; and that Proclus in the same way destroyed the navy of Vitellius, at the siege of Byzantium.

There are also passages in some of the ancients, which seem to indicate that they also possessed a knowledge of the burning powers of refractors, although their magnifying powers appear to have been wholly unknown to them. Among the moderns, one of the earliest who devised a burning mirror, was the celebrated Lord Napier, the inventor of logarithms.

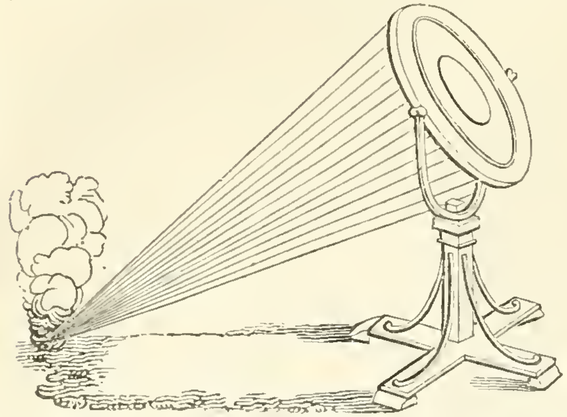
Of the moderns, the most remarkable burning glasses are those of Magine, of 20 inches diameter; of Sepatala, of Milan, near 42 inches diameter, and which burnt at the distance of 15 feet; of Settala, of Vilette, of Tschirnhausen, of Buffon, of Trudaine, and of Parker.

That of M. de Vilette was 3 feet 11 inches in diameter, and its focal distance was 3 feet 2 inches. Its substance is a composition of tin, copper, and tin glass. Some of its effects, as found by Dr. Harris and Dr. Desaguliers, are, that a silver sixpence melted in 7½″; a king George's halfpenny melted in 16″, and ran in 34″; tin melted in 3″; and a diamond, weighing 4 grains, lost ⅞ths of its weight.

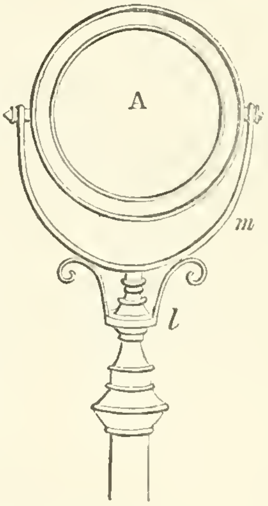
That of Buffon is, (see Archimedes' mirror, in the following figure,) a polyhedron, 6 feet broad, and as many high, consisting of 168 small mirrors, or flat pieces of looking-glass, each 6 inches square, by means of which, with the faint rays of the sun in the month of March, he set on fire boards of beech wood at 150 feet distance. Besides, his machine has the conveniency of burning downwards or horizontally, as one pleases, each speculum being moveable, so as, by means of three screws, to be set to a proper inclination for directing the rays towards any given point; and it turns either in its greater focus, or in any nearer interval, which our common burning glasses cannot do, their focus being fixed and determined. Buffon, at another time, burnt wood at the distance of 200 feet; and melted tin and lead at the distance of more than 120, and silver at 50 feet.



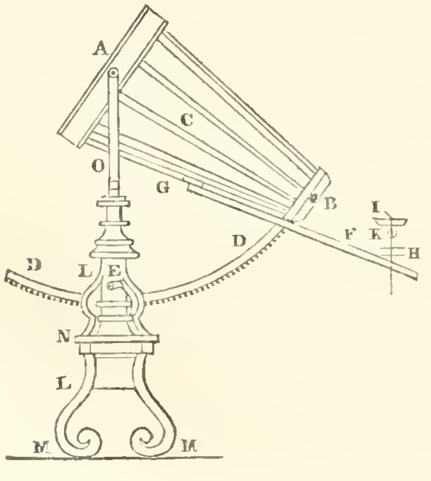
The following figure represents another contrivance of Buffon, for diminishing the thickness of very large refracting lenses, in which the burner consists of concentric pieces of glass, each resting upon the other, as represented in the figure, by dividing the convex arch of the lens into three equal parts. Thus, suppose the diameter to be 26 inches, and the thickness in the middle 3 inches; by ÷ the lens into three concentric ○'s, and laying the one over the other, the thickness of the middle piece need only be *one inch;* at the same time that the lens will have the same convexity, and almost the same focal distance, as in the other case, while the effects of it must be much greater on account of the greater thickness of the glass.



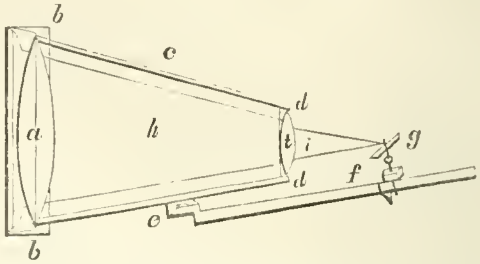
Mr. Parker, of Fleet-street, London, was induced, at an expense of upwards of £700, to contrive, and at length to complete, a large transparent lens, that would serve the purpose of fusing and vitrifying such substances as resist the fires of ordinary furnaces, and more especially of applying heat in vacuo, and in other circumstances in which it cannot be applied by any other mean, as in the annexed figure. After directing his attention for several years to this object, and performing a great variety of experiments in the prosecution of it, he at last succeeded in the construction of a lens of flint glass, 3 feet in diameter, which, when fixed in its frame, exposes a surface of 32 inches in the clear; the distance of the focus is 6 feet 9 inches, and its diameter 1 inch. The rays from this large lens are received and transmitted through a smaller one of 13 inches diameter, its focal length 29 inches, and diameter of its focus $\frac{3}{8}$ inch; so that this second lens increases the power of the former, as 8^2 to 3^2, or rather more than 7 to 1.



In the elevation, (as in the following figure,) A is the lens of the diameter mentioned; B is a second lens, 16 inches diameter; C a truncated cone, composed of 21 ribs of wood, in which both lenses are fixed; D is a rack passing through the pillar L, E its handle; F a bar of wood, fixed between the two lower ribs of the cone at G, in which the apparatus H, with the iron plate I, turning on the ball and socket K, to hold thereon the matter under experiment; L L a frame moving on the castors M M. Below the table N are three friction wheels, that move the machine horizontally. O a strong iron bar, in which the lens and the cone hang.



The following figure represents the section. *a* is the great lens marked A in the elevation; *b* the frame containing the great lens; *t* the small lens marked B; *d* the frame that contains the small lens; *e* the truncated cone C; *f* the bar on which the apparatus F turns; *g* the iron plate marked I; *h* the cone of rays formed by the great lens *a* falling on the lens *t*; *i* the cone of rays formed by the refraction of the lens *t*. In the front view in Mr. Parker's lens, A is the great lens in its circular frame; *m* the iron bow in which it hangs; *l* the support.



From a variety of experiments made with this lens, the following are selected to serve as a specimen of its powers:—

Substances fused, with their Weight and Time of Fusion.	Weight in Grains.	Time in Seconds.
Gold,....pure,	20	4
Silver, .. ditto,	20	3
Copper, ditto,	33	20
Platina, ditto,	10	3
Nickel,	16	3
Bar iron, a cube,	10	12
Cast iron, ditto,	10	3
Steel, ... ditto,	10	12
Scoria of wrought iron,	12	2
A topaz, or chrysolite,	3	45
An oriental emerald,	2	42
Crystal pebble,	7	6
Topaz,	10	30
Flint oriental,	10	30
Rough cornelian	10	75
Jasper,	10	25
Onyx,	10	20
Garnet,	10	17
White rhomboidal spar,	10	60

Mr. Parker farther informs us, that a diamond weighing 10 grains, exposed to this lens for 30 minutes, was reduced to 6 grains; but gold remained in its metallic state, without apparent diminution, notwithstanding an exposure at intervals of many hours. With regard to experiments on iron, it is remarkable that the lower part, *viz.* the part in contact with the charcoal, was first melted, when that part which was exposed to the focus remained unfused. For farther particulars on this subject see Rees's Cyclopedia, article Burning Glass; see also an essay on "Mirrors Ardens," by M. Peyrard, subjoined to the French translation of the works of Archimedes.

BURTHEN, or BURDEN, the weight or measure of any species of merchandise that a ship will carry when fit for sea; the general rule for finding which is, to multiply the length of the keel, the inner midship breadth, and the depth from the main deck to the plank joining the keelson, together; which product divided by 94 gives the tonnage, or burden, required in tons.

BUSHEL, a measure for dry goods, which by an act of parliament, passed in 1697, is to contain 2150·42 cubic inches, *viz.* "Every round bushel, with a plain and even bottom, is to be made 18½ inches wide throughout, and 8 inches deep, which is accounted a legal Winchester bushel, according to the standard in his majesty's exchequer." *See* Weights and Measures.

BUTTER, Cheese, &c.—Butter is an artificial preparation of cow's milk. The milk, either in its natural state or in that of cream, is whirled round or agitated in a churn, till all its unctuous particles are separated from the whey, and a soft consistent mass is formed.* Greek authors frequently speak of milk and cheese, but do not mention butter; and the Romans, for six centuries, used it as a medicine. In modern times, the art of making, improving, and preserving butter, has kept pace with the unwholesome custom of eating this animal oil from an early period of infancy. Butter forms a considerable article of trade. 50,000 tons of butter are annually consumed in London; of which the counties of Cambridge and Suffolk are said to furnish 50,000 firkins, each containing 56 lbs. None, however, is equal to that produced in Essex, and known by the name of Epping butter.

Butter, like all inflammable substances, is constantly undergoing oxygenation, as the chemists call it, and by this process becomes rancid, or is changed into a new substance no longer suitable for the purposes of nourishment. The tendency to rancidity, or oxygenation, is much hastened by its greater or less admixture with the other parts of the milk, from which it is not totally freed; for if the parts are very completely separated, the progress of oxygenation is much retarded.

The only means of preserving butter is by means of sea-salt; and with this addition it can be kept long in a fit condition for aliment. The cream, or oily part of the milk, from which butter is made, acquires, by being kept for some time, new properties, and these new properties facilitate its conversion into butter. Thus sour cream does not take one-fourth part of the labour necessary in churning, as fresh cream, in order to give out its product: but this acid which prevails in the cream before churning, disappears also after the process is finished; and this circumstance is no way influenced either by the access or exclusion of the atmospheric air. Fresh butter, as first made, is almost without any smell, of a mild and agreeable taste, easily soluble in water, and remaining uniform even in a boiling heat. As its acid becomes extricated, it acquires an acrimony or rancidity, and is then rendered unwholesome.—This acid is peculiar, and has not yet been properly examined.

The proper quality of butter is marked by its oily or fat shining surface, and its yellow colour, with an agreeable flavour and sweetish taste. The colour varies according to the feeding of the animal, and to supply its defect, adventitious means are often resorted to by colouring it with vegetables. The highest degree of natural colour is generally found in that from the milk of Guernsey cows. From the strong tendency of butter to oxygenation, great quantities of this article come to be sold in a rancid state; and this cannot fail to be attended with the most deleterious consequences, and to lay the foundation of disease. As the wholesomeness of this article depends on its freedom from rancidity, whatever operation it is subjected to, that produces this state of it, introduces the foundation of disease, whether it arise from keeping, or the processes of cookery in frying and burning. It becomes in this state heavy and indigestible on the stomach, occasioning acrid and acid belchings.

But besides selling it in a rancid state, other deceptions may be adduced in respect to butter, by those who deal in it. By beating, it possesses the quality of absorbing an immense quantity of water. Such advantage is taken of this circumstance, that what with the additional weight of salt also introduced into it, the public do not receive more than two-thirds of the actual product when they buy it. The fraud begins from the very dairy, and is increased when it gets into the hands of the cheesemonger. The poor man is deprived of so much of the nourishment which he ought to have, and, by an excess of extraneous matter introduced into his body, through the use of this sophisticated article, sees himself and his progenitors often suffering under scrofula and other maladies, drawing their origin from, or aggravated by, this impure source.

Cheese, made from curdled milk, freed from the serum or whey, and afterwards dried for use, differs in quality, as it is made from new milk, or from skimmed milk,—from the curd which separates spontaneously upon standing, or that which is more speedily produced with runnet. There is also cheese from cream, which is fat and butyraceous, and does not keep long. Of all the cheese made in England, none is so esteemed as the Stilton. These cheeses must be kept two years before they are properly mellowed for use in families. The making of what is called Stilton cheese is not confined to the Stilton farmers. Others in Huntingdonshire, and even in Rutland and Northamptonshire, make a similar sort, which is sold under the name of Stilton. The double Gloucester is much esteemed. The goodness of Chedder cheese is said to be owing to the richness of the land: the same is the case with the Somersetshire, and that of the adjoining counties. Cheshire cheese is generally admired. A cheese is sometimes above a hundred pounds weight. To give a high colour to cheese, it is usual to put with the milk, before it is turned, a little annotto. No cheese will look yellow without it, and though it is perfectly innocent, it does not add to the goodness of the cheese.

BUTTERFLY, *To take the Impression of a.* Having caught a butterfly, kill it without spoiling its wings, contrive to spread these out as regularly as possible in a flying position; then, with a small brush or pencil, take a piece of white paper; wash part of it with gum water, afterwards lay your butterfly on the paper, cut off the body close to the wings, throw it away, lay the paper on a smooth board, with the fly upwards; lay another paper over that, put the whole preparation into a screw press, and screw it hard down, or otherwise press it, for half an hour. Afterwards take off the wings of the butterfly, and you will find their perfect impression, with all their various colours marked distinctly, on the paper. When this is done, draw between the wings of your impression the body of the butterfly, and colour it after the insect itself.

---

* There are also vegetable butters made from palm oil, and the oil of the cocoa nut. The celebrated Park found, in Africa, a tree called by the natives shea, from the fruit of which a tolerably pure butter was procured.

C.

CABIN, a room or apartment in a ship, where any of the officers usually reside. In a large ship there are several cabins, the principal of which, distinguished by the name of the great cabin, is designed for the captain or commander. In ships of the line, this chamber is furnished with an open gallery in the ship's stern, as also a little gallery on each quarter.

CABINET, a secret or inner apartment; also a piece of joiner's work resembling a press or chest; likewise a council, or select meeting, is called a cabinet.

CABLE, a thick, stout rope, made of hemp, &c. to keep a ship at anchor. Every cable is of three strands, every strand of three ropes, every rope of three twists; and the twists are spun of more or less threads, as the cable is to be thick or small. Thus, a cable of one inch diameter, or three inches circumference, consists of forty-eight ordinary threads, and weighs 192 pounds. To estimate the strength of a hempen cable, divide by 5, the square of its girth in inches, and the quotient will express in tons the utmost strain it can bear.

Hence, a rope of 1 inch diameter is capable of bearing a strain of 1·8 ton.

Circum.	Thread.	Weight.—lbs.	Strain.—Tons.
4	77	308	3·2
6	174	696	7·2
8	311	1244	12·8
10	485	1940	20·0
14	952	3808	39·2
18	1574	6296	64·8
20	1943	7772	80·0

This estimate applies to new ropes, formed of the best materials, not much twisted, and having the strands laid even. If yarns, of 180 yards long, be worked up into ropes 120 yards only, it will lose one-fourth of the strength, the exterior fibres alone resisting the greatest strain.

The long cable is not so apt to break as the short one, because it will bear a great deal more stretching before it comes to the greatest strain; it therefore resembles a sort of spring, which may be very easily extended, and afterwards recovers its first state, as soon as the force which extended it is removed. Besides all this, a ship will ride much smoother with a long cable, and be less apt to pitch or plunge deep in the water with the fore part. On the contrary, the short cable, being too nearly vertical to the anchor, cannot bear such a strain, because it is charged with a greater effort; and, as it will not bear stretching, may break the first violent tug. The ship also rides with much greater difficulty, labours extremely, and often plunges all her fore part under water. Every ship should be furnished with sufficiency of cables, or what is called ground tackle; for owing to a deficiency of this necessary article, many excellent vessels have been lost, and it is an inconsiderate policy indeed, in merchants, to expose their ships to such evident dangers for the want of them.

CAGE, an enclosure of wire, or wicker, for the confinement of birds or wild beasts. Cage means also, in carpentry, some outer work, or timber enclosing other timber, as, the cage of a windmill; the cage of a staircase, the wooden walls or sides that enclose it.

CALAMINE, a mineral composed of zinc, iron, and sometimes other substances; its colour is sometimes whitish or gray; at other times brown or blackish, red or deep yellow.

CALAMUS, the rotang, or true Indian cane, abundant in Sumatra, is one of those plants from which the drug, called dragon's blood, is obtained.

CALASH, a small light chariot, or garden chair, of which a new sort going on two wheels has been invented; not hung on traces and springs, yet easier than the common coaches, and possessing the singular advantage of recovering its proper position, should it, by any irregularity of the road, or other accident, be overturned.

CALCAR, a small oven, or reverberatory furnace, in which the first calcination of sand and potashes is made, for turning them into *frit*, from which glass is ultimately made. This furnace, 10 feet long, 7 wide, 2 deep, is heated by flame reverberating from the roof upon the frit, over the surface of which the smoke rolls quite black, escaping by the mouth of the calcar. The coals burn on grates of iron, to allow the ashes to precipitate.

CALCAREOUS Earth, the same as lime, and of which there are various combinations, as marble, limestone, marle, gypsum. Vast quantities of marine shells, and the bones of animals, are found imbedded in it.

CALCINATION. *See* Chemistry.

CALCULATION, the act of computing, as in Arithmetic, Astronomy, Geometry, &c.

CALCULUS, among Mathematicians, denotes a certain way of performing mathematical operations.

Calculus, in Medicine, the disease of the stone in the bladder or kidneys; the term is Latin, and signifies a *little pebble*. Hard waters, that contain limy earth, contribute to the formation of human calculi.

CALENDAR, in Chronology, a distribution of time, accommodated to the purposes of civil life, exhibiting the order of days, weeks, months, festivals, &c. that happen and succeed in the course of one year. The calendar of Romulus, or the ancient Romish year, consisted of ten months, namely, *Martius* of thirty-one days, *Aprilis* of thirty, *Maius* of thirty-one, *Junius* thirty, *Quintilis*, of thirty-one, *Sextilis* of thirty, *September* of thirty, *October* of thirty-one, *November* of thirty, *December* of thirty; in all, three hundred and four days.

The Roman year of Numa consisted of twelve months. *Januarius* had twenty-nine days, *Februarius* twenty-eight, *Martius* thirty-one, *Aprilis* twenty-nine, *Maius* thirty-one, *Junius* twenty-nine, *Quintilis* thirty-one, *Sextilis* twenty-nine, *September* thirty-one, *October* twenty-nine, *November* twenty-nine; *December* twenty-nine; in all, three hundred and fifty-five. The months called Quintilis and Sextilis, from their order in Romulus's year, were changed into Julius and Augustus, in honour of Julius Cæsar and his successor Augustus.

The *Julian* year consists of twelve months, *viz. January* of thirty-one days, *February* of twenty-eight, *March* of thirty-one, *April* of thirty, *May* of thirty-one, *June* of thirty, *July* of thirty-one, *August* of thirty-one, *September* of thirty, *October* of thirty-one, *November* of thirty, *December* of thirty-one; in all three hundred and sixty-five. Every fourth year, in the Julian account, has three hundred and sixty-six days, February then having twenty-nine, as we have before observed. The *Gregorian* year has the same number of months and days as the Julian, the only difference being that each month in the former begins *eleven* days sooner than the latter.

The *Jewish* year consists of twelve months. *Nisan* or *Abib* has thirty days, *Jiar* or *Zius* twenty-nine; *Siban* or *Sivan* thirty, *Thamus* or *Tamus* twenty-nine, *Ab* thirty, *Elul* twenty-nine, *Tisri* or *Ethanim* thirty, *Marchesvan* or *Bul* twenty-nine, *Cisleu* thirty, *Tebeth* twenty-nine, *Shebat* or *Schebeth* twenty-nine, *Adar* twenty-nine; in all three hundred and fifty-four. This is made to agree with the *solar year*, by adding eleven, and sometimes twelve days.

As the form of the year is various among different nations, so likewise is its beginning. The Jews, like other nations of the East, had a civil year, which commenced with the moon in September; and an ecclesiastical year, which began from the new moon in March. The Persians begin their year in the month answering to June. The Chinese and most of the Indian nations begin it with the first moon in March; and the Greeks with the new moon that happens next after the summer solstice.

In England, the civil or legal year formerly commenced on the 25th of March, and the historical year on the first day of January. But since the alteration of the style, in 1752, the civil year, in this country, as we observed before, has likewise begun on the first of January.

CALENDS, or Kalends, in the Roman Chronology, the first day of every month. It was one of the offices of the pontifices to watch the appearance of the new moon, and give notice thereof to the high priests; upon which a sacrifice being offered, the pontiff summoned the people together in the Capitol, and there with a loud voice proclaimed the number of calends, or the day whereon the nones would be; which he did by repeating a formula as often as there were days or calends. And hence also our term calendar.

The *Nones* were the 5th day of January, February, April, June, August, September, November, and December, and the 7th of March, May, July, and October. And the *Ides* happened 9 days after the nones; that is, on the 13th day of February, April, June, August, September, November, and December; and on the 15th of March, May, July, and October.

CALIBER, or Caliper, properly denotes the diameter of any round body: thus we say the caliber of the bore of a gun, the caliber of a shot, &c.

Caliber or Caliper *Compasses*, or simply *Calipers*, a sort of compass made with bowed or arched legs, for the purpose of taking the diameter of any round body.

CALICO, a cloth made from cotton wool, resembling linens; the name is from Calicut, a city in India, from whence the Spaniards or Portuguese first brought calicoes.

Calico-Printing, or the art of applying coloured patterns on a white or coloured ground of linen or cotton, has been practised in India for more than two thousand years, but has not been cultivated in Europe more than a century. This art depends on the action of certain bodies, which, by chemical agency, permanently unite the colouring matter of dyeing materials to particular parts of the cloth. The substances which bind the colouring matters to the faces of the cloth, are denominated mordants. The mordant is applied to the cloth by wooden blocks, in which the patterns are carved in relief. This effect is also produced by means of a small brush, by sheet copper fixed in a block, like filligree work, or by the copper-plate. When the mordant has been applied, the cloth is made completely dry; and washed in water, till the thickening matter, and those parts of the mordants uncombined with the cloth, are removed. After this, the cloth is rinsed in clean water. It is then dipped in the dye liquor, by which the whole is dyed. The parts which have been impregnated in the mordant receive a brighter colour than those which have not. The colour of the former is permanent, but that of the latter is discharged by repeated washing.

Calico-printing, we have said, consists in impregnating those parts of the cloth which are to receive a colour, with a mordant, and then dyeing it as usual with some dye stuff or other. The dye stuff attaches itself firmly to that part of the cloth only which has received the mordant. The whole surface of the cotton is indeed more or less tinged, but by washing and bleaching, all the unmordanted parts resume their original colour, while those which have received the mordant retain it. Let us suppose, that a piece of white cotton cloth is to receive red stripes; all the parts where the stripes are to appear are pencilled over with a solution of acetite of alumine; after this, the cloth is dyed in the usual manner with madder. When taken out of the dyeing vessel it is all of a red colour, but by washing and bleaching, the madder leaves every part of the cloth white, except the stripes impregnated with the acetite of alumine, which remain red. Thus it is obvious, that it is not the cloth but the mordant which has retained the dye. In the same manner may yellow stripes, or any other wished-for figure, be given to cloth, by substituting quercitron bark, weld, &c. for madder.

When different colours are to be given to different parts of the cloth at the same time, it is done by impregnating it with various mordants. Thus, if stripes be drawn upon a cotton cloth with acetite of alumine, and other stripes with acetite of iron, and the cloth be afterwards dyed in the usual way with madder, and then washed and bleached, it will be striped red and brown. The same mordants with quercitron bark, give yellow and olive, or drab.

The mordants employed in calico-printing are, acetite of alumine, and acetite of iron. These mordants are applied to the cloth, either with a pencil, or by means of blocks. As the mordants are applied on to particular parts of the cloth, care must be taken that none of them spread to the part of the cloth which is to be left white, and that they do not interfere with one another, when more than one are applied. If these precautions be not attended to, all the elegance and beauty of the print will be destroyed.

It is necessary, therefore, that the mordants should be of such a consistence, as not to spread beyond those parts of the cloth on which they are applied. This is done by thickening them with flour or starch, when they are to be applied by the block; and with gum arabic, when they are to be put on by a pencil. The thickening should never be greater than is sufficient to prevent the spreading of the mordants; when carried too far, the cotton is apt not to be sufficiently saturated with the mordants; and of course, the dye takes but imperfectly. In order that the parts of the cloth impregnated with mordants may be distinguished by their colour, it is usual to tinge the mordants with some colouring matter or other. The printers commonly use the decoction of Brazil wood for this purpose; but the Brazil wood colouring matter impedes the subsequent process of dyeing. The mordant should therefore be coloured with some of the dye stuff afterwards to be applied, but not more than is sufficient to make the mordant distinguishable when applied to the cloth. The reason is obvious. If too much dye be mixed with the mordant, a great proportion of the mordant will be combined with colouring matter, which must weaken its affinity for the cloth, and of course prevent it from combining with it in sufficient quantity to ensure a permanent dye. Sometimes these two mordants are mixed together in different proportions; and sometimes one or both is mixed with an infusion of sumach, or of nut galls. By these contrivances a great variety of colours are produced by the same dye stuff. After the mordants have been applied, the cloth is dried by artificial heat, which contributes towards the separation of the acetous acid from its base, and towards its evaporation, by which the mordant combines in a greater proportion, and more intimately with the cloth.

When the cloth is sufficiently dried, it is to be washed with warm water and cow-dung, till all the flour, or gum, employed to thicken the mordants, and all those parts of the mordants which are uncombined with the cloth, be removed. After this, the cloth is thoroughly rinsed in clean water. Almost the only dye stuffs employed by calico-printers, are indigo, madder, and quercitron bark, or weld. This last substance, however, is but little used by the printers of this country, except for delicate greenish yellows. The quercitron bark has almost superseded it, because it gives colours usually good, and is much cheaper and more convenient, not requiring so great a heat to fix it. Indigo not requiring any mordant, is commonly applied at once, either with a block or a pencil. It is prepared by boiling together indigo, potash made caustic by quicklime, and orpiment; the solution is afterwards thickened with gum. It must be carefully secluded from the air, otherwise the indigo would soon be regenerated, which would render the solution useless. Coarse brown sugar, as a substitute for orpiments, is equally efficacious in decomposing the indigo, and rendering it soluble; while it likewise serves all the purposes of gum.

When the cloth, after being impregnated with the mordant, is sufficiently cleansed, it is dyed in the usual manner, and the whole is more or less tinged with the dye stuff. It is well washed, and then spread out for some days on the grass, and bleached with the wrong side uppermost. This carries the colour off completely from all parts of the cotton which have not imbibed the mordant, and leaves them of their original whiteness, while the mordanted spots retain the dye as strongly as ever.

We will now give some examples of the manner in which printers give particular colours to calicoes. Some calicoes are only printed of one colour, others have two, others three or more, even to the number of eight, ten, or twelve. The smaller the number of colours, the fewer in general are the processes.

One of the most common colours on cotton prints is a kind of nankeen yellow, of various shades, down to a deep yellowish brown, or drab. It is usually in stripes or spots. To produce it, the printers besmear a block, cut out into the figure of the print, with acetite of iron, thickened with gum or flour; and then apply it to the cotton, which, after being dried and cleaned in the usual manner, is plunged into a potash ley. The quantity of acetite of iron is always proportioned to the depth of the shade. For yellow, the block is besmeared with acetite of alumine. The cloth, after receiving the mordant, is dyed with quercitron bark, and then bleached. Red is communicated by the same process, only madder is substituted for the bark. The fine light blues which appear so often on printed cottons, are produced by applying to the cloth a block besmeared with a composition, consisting partly of wax, which covers all those parts of the cloth which are to remain white. The cloth is then dyed in a cold indigo vat; and after it is dry, the wax composition is removed by hot water.

Lilac brown, and blackish brown, are given by means of acetite of iron; the quantity of which is always proportioned to the depth of the shade. For very deep colours, a little sumach is added. The cotton is afterwards dyed in the usual manner with madder, and then bleached.

Dove colour and drab, by acetite of iron and quercitron bark. When different colours are to appear in the same print, a greater number of operations are necessary. Two or more blocks are employed, upon each of which, that part of the print only is cut, which is to be of some particular colour. These are besmeared with different mordants, and applied to the cloth, which is afterwards dyed as usual. Let us suppose, for instance, that these blocks are applied to cotton, one with acetite of alumine, another with acetite of iron, a third with a mixture of those two mordants, and that the cotton is then dyed with quercitron bark, and bleached. The parts impregnated with mordants would have the following colours:—Acetite of alumine, yellow; acetite of iron, olive, drab, dove; the mixture, olive green, olive.

If the part of the yellow be covered over with the indigo liquor, applied with a pencil, it will be converted into green. If the same liquid, blue may be given to such parts of the print as require it. If the cotton be dyed with madder, instead of quercitron bark, the print will exhibit the following colours:—Acetite of alumine, red; acetite of iron, brown, black; the mixture, purple.

When a greater number of colours are to appear; for instance, when those communicated by bark, and those by madder, are wanted at the same time, mordants for part of the pattern are to be applied; the cotton is then to be dyed in the madder bath, and bleached; then the rest of the mordants, to fill up the pattern, are added, and the cloth is again dyed with quercitron bark, and bleached. The second dyeing does not much affect the madder colours; because the mordants, which render them permanent, are already saturated. The yellow tinge is easily removed by the subsequent bleaching. Sometimes a new mordant is also applied to some of the madder colours, in consequence of which, they receive a new permanent colour from the bark. After the last bleaching, new colours may be added by means of the indigo liquor. The following table will give an idea of the colours which may be given to cotton by these complicated processes.—1. *Madder Dye.* Acetite of alumine, red; acetite of iron, brown, black; acetite diluted, lilac; both mixed, purple.—2. *Bark Dye.* Acetite of alumine, yellow; acetite of iron, dove, drab; lilac and acetite of alumine, olive; red and acetite of alumine, orange. —3. *Indigo Dye.* Indigo, blue; indigo and yellow, green.

Thus no less than twelve colours may be made to appear together in the same print, by these different processes. These instances will serve to give the reader an idea of the nature of calico-printing, and at the same time afford an excellent illustration of the importance of mordants in dyeing.

Were it possible to procure colours sufficiently permanent, by applying them at once to the cloth by the block or the pencil, as is the case with the mordants, the art of calico-printing would be brought to the greatest simplicity; but at present this can only be done in one case, that of indigo; every other colour requires dyeing. Compositions, indeed, may be made, by previously combining the dye stuff and the mordants. Thus yellow may be applied at once, by employing a mixture of the infusion of quercitron bark and acetite of alumine, red, by mixing the same mordant with the decoction of alumine, and so on. The colours applied in this way, are, unfortunately, far inferior in permanency to those produced when the mordant is previously combined with the cloth, and the dye stuff afterwards applied separately. In this way are applied almost all the fugitive colours of calicoes, which washing, or even exposure to the air, destroys.

CALIPPIC *Period*, in Chronology, a period of 76 years, continually recurring, after which it was supposed by Calippus, that the lunations, &c. of the moon would return again in the same order; which, however, is not exact, as it brings them too late by a day in 225 years.

CALOMEL, dulcified sublimate of mercury, is a combination of mercury with muriatic acid; called also *sub-muriate of mercury*.

CALORIC, in Chemistry, a modern term introduced into philosophy, to denote that substance, by the influence of which are produced all the phenomena of heat, and which was formerly distinguished by the term *igneous fluid*, *matter of heat*, and other analogous demonstrations.

Heat, considered as a sensation, or, in other words, sensible heat, is only the effect produced upon our organs by the motion of caloric, disengaged from surrounding bodies. To illustrate this, let us observe, that in general we receive the impression only in consequence of motion, and it might be established as an axiom, that without motion there is no sensation. This general principle applies very accurately to the sensations of heat and cold. When we touch a cold body, the caloric, which always exerts itself to attain an equilibrium in all bodies, passes from our hand into the body we touch, and give us the feeling or sensation of cold. The contrary happens when we touch a warm body; the caloric then, in passing from the body into our hand, produces the sensation of heat. If the hand and the body it touches be of the same temperature, or very nearly so, we receive no impression of either heat or cold, because there is no motion or passage of caloric. When the thermometer rises, it shews that the free caloric is entering into the surrounding bodies. The thermometer, which is one of these, receives it in proportion to its mass, and to the capacity which it possesses for containing caloric. Free caloric is that which is not combined in any manner with any body. But as we live in a system, to the matter of which caloric has a very strong affinity, we are never able to obtain it in a state of absolute freedom.

Combined CALORIC is that which is fixed in bodies by affinity, or elective attraction, so as to form part of the substance of the body.

Specific CALORIC. By the expression of specific caloric of bodies, we understand the respective quantities of caloric requisite for raising a number of bodies, of the same weight, to an equal degree of temperature. This proportional quantity of caloric depends upon the distance between the constituent particles of bodies and their greater or less degree of cohesion; and this distance, or rather the space or void resulting from it, is called the capacity of bodies for containing caloric. Caloric is the cause of fluidity and of vapour.

Bodies which transmit caloric easily, are called conductors of caloric; and according to the power of doing this, they are termed good or bad conductors. Those which do not transmit heat at all, or with great difficulty, are called non-conductors. The best conductors of heat are metals, and the best non-conductors of fluids are water and air. Charcoal is also considered as a non-conductor. Heat is produced by collision, friction, chemical action, the solar rays, electricity, galvanism, &c. The instruments for measuring its intensity are called Pyrometers. *See* FIRE.

CALX, lime, but a dignified title for any powder remaining after burning a metal; and because in burning the metal imbibes oxygen, and the powder from it becomes heavier than the metal was before, all metallic calces are now-a-days called *oxides*, and rust is also an oxide.

CAMBLET, a stuff made of wool, hair, or silk, and sometimes of all these mixed.

CAMBRIC, a species of linen made of flax, very fine and white, deriving its name from Cambray, in France, where this cloth was first made.

CAMEL is the name given to a machine, employed by the Dutch for carrying vessels heavily laden over the sandbanks in the Zuyder-Zee. In that sea, opposite to the mouth of the river Y, about six miles from the city of Amsterdam, there are two sandbanks, between which is a passage called the Pampus, sufficiently deep for small vessels, but not for those which are large and heavily laden. On this account, ships which are outward bound take in before the city only a small part of their cargo, receiving the rest when they have got through the Pampus. And those that are homeward bound must, in a great measure, unload before they enter it. For this reason, the goods are put into lighters, and in these transported to the warehouses of the merchants in the city; and the large vessels are then made fast to boats by means of ropes, and in that manner towed through the passage to their stations.

Though measures were adopted so early as the middle of the sixteenth century, by forbidding ballast to be thrown into the Pampus, to prevent the further accumulation of sand in this passage, that inconvenience increased so much from other causes as to occasion still greater obstruction to trade; and it at length became impossible for ships of war, and others heavily laden, to get through it. About the year 1672 no other remedy was known than that of making fast to the bottoms of ships large chests filled with water, which was afterwards pumped out; so that the ships were buoyed up, and rendered sufficiently light to pass the shallow. By this method, which was attended with the utmost difficulty, the Dutch carried out their numerous fleet to sea in the above-mentioned year. This plan, however, gave rise soon after to the invention of the camel, by which the labour was rendered easier.

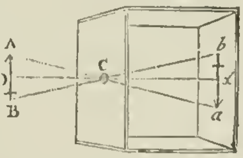
The camel consists of two half ships, constructed in such a manner that they can be applied below water, on each side of the hull of a large vessel. On the deck of each part of the camel are a great many horizontal windlasses, from which ropes proceed through apertures in the one half, and, being carried under the keel of the vessel, enter similar apertures in the other, from which they are conveyed to the windlasses on its deck. When they are to be used, as much water as may be necessary is suffered to run into them; all the ropes are cast loose, the vessel is conducted between them, and large beams are placed horizontally through the port holes of the vessel, with their ends resting on the camel on each side. When the ropes are made fast, so that the ship is secured between the two parts of the camel, the water is pumped from them, by which means they rise, and float the ship with them. Each half of the camel is about 130 feet long, and 22 to 13 feet broad. The hold is divided into several compartments, that the machine may be kept in equilibrio while the water is flowing into it. A vessel drawing 15 feet water, can be made to draw only 11 by the camel; and ships of war of 100 guns, can be raised to pass without grounding the shallow banks of the Zuyder-Zee. The Russians* employ similar machines to float vessels built in the Neva, over the intermediate sand-banks. Camels are also used at Venice.

CAMELOPARDALIS. The Camelopard is a modern constellation, that has been formed by Hevelius. Its boundaries and contents are: north by the pole of the world, east by Ursa Major and Lynx, south by Perseus and Auriga, and west by Perseus, Cassiopeia, and Tarandus; right ascension 68°, declination 70° north. It consists of 58 small stars, five of the fourth magnitude, and the rest smaller. The most conspicuous star is nearly on the Arctic Circle, on the near hind thigh. This constellation extends from Auriga to the North Pole, by which position it can be the better traced in the heavens.

CAMERA LUCIDA, or *Light Chamber*, a contrivance of Dr. Hook, to make the image of any object appear on a wall, in a light room, either by day or night. Dr. Wollaston has recently invented a portable instrument for drawing in perspective, to which he has given the name of *camera lucida.*

CAMERA *Obscura*, or *Dark Chamber*, in Optics, a machine or apparatus, so constructed, that principally by means of a convex glass, or a convex glass and plane mirror, the images of external objects are represented on a rough ground plane glass, white paper, or other surface, in the most vivid and distinct manner, with all their natural colours, motions, &c.

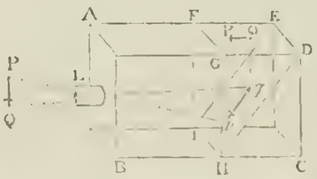
The use of the Camera Obscura is various: it assists very much in explaining the nature and rationale of vision; and hence by some it has been compared to an artificial eye. It exhibits the most striking and entertaining representations of objects of all descriptions, whether near or distant, in their true perspective; the colouring just and natural, their light and shadows correct, and all their motions and relative positions according to the original. By means of this instrument, a person, however unacquainted with drawing, may delineate objects with great facility and correctness; and to the skilful artist it will be found indispensably useful in comparing his sketches with the perfect representations given in the camera; and by observing his defective imitations, he may correct as much as possible his designs.



The theory of the Camera Obscura will be readily comprehended from the annexed figure, in which the object A B radiates through a small aperture, C, upon a white wall opposite to it, and if the place of radiation behind the aperture bCa be dark, the image of the object will be painted on the wall, in an inverted position; for the aperture C being very small, the rays issuing from the point B will fall on b; those from points A and D will fall on a and d; wherefore, since the rays issuing from the several points are not confounded, they will by reflection exhibit its appearance on the wall. But since the rays A C and B C intersect each other in the aperture, and the rays from the lowest points fall on the highest, the situation of the object will of necessity be inverted. If the wall where the object is delineated be parallel to it, $ab : AB :: dC : DC$, that is, the height of the image will be to the height of the object, as the distance of the image from the aperture is to the distance of the object from the same.

To construct a permanent Camera Obscura.—1. Darken a chamber, one of whose windows looks into a place set with various objects; leaving only a little aperture open in one shutter. 2. In this aperture fit a lens, either plano-convex, or convex on both sides, so as to be a portion of a large sphere. 3. At a due distance, to be determined by experience, spread a paper, or white cloth, unless there be a white wall for the purpose; for on this the images of the desired objects will be delineated invertedly. 4. If it be rather desired to have them appear erect, it is done either by means of a concave lens placed between the centre and the focus of the first lens; or by receiving the image on a plane speculum inclined to the horizon under an angle of 45°; or by means of two lenses included in a drawtube, in lieu of one.—*Note.* If the aperture do not exceed the size of a pea, the objects will be represented, even though no lens be used.

That the images be clear and distinct, it is necessary that the objects be illuminated by the sun's light shining upon them from the opposite quarter; so that, in a western prospect, the images will be best seen in a forenoon; an eastern prospect, the afternoon; and a northern prospect, about noon: a southern prospect is the least eligible of any. But the best way is to have the lens fixed in a proper frame, on the top of a building, and made to move easily round in all directions, by a handle extended to the person who manages the instrument; the images being then thrown down into a dark room immediately below it, upon a horizontal round plaster of Paris ground: for thus a view of all the objects quite around may easily be taken in the space of a few minutes; as is the case of the excellent Camera Obscura placed on the top of the royal observatory at Greenwich, and with a very good one made by Holroyd of Leeds, in which the images are received on a table of more than six feet diameter.



A very simple portable Camera Obscura is represented in the annexed figure. A B C D is a small rectangular box, its length being about 20 or 24 inches, and its breadth about 10 inches. This box is closed on all sides, except the space E F G D, which is covered with a piece of ground glass, or transparent paper. In the other end, A B, is a moveable tube, L, with a proper lens, and E I H D is a plane reflecting mirror (set at an angle of 45°) which intercepts the rays P p, Q q, &c. proceeding from the object P Q, which are thence reflected upon the transparent skreen E F G D, where the image of the object will be painted in its natural colours, but in an inverted position, as Q P; which, however, may be obtained erect, by the introduction of proper lenses in the tube L.—*Note.* That a shade is necessary to keep off the external light from the skreen E F G D, which is commonly effected by having the box covered with a horizontal lid, under which are two wings which open at right angles to each side of it. Various other forms are given to this instrument.

CAMP, the ground on which an army pitch their tents. The Roman camp was a square, fortified with a ditch and parapet, and sometimes with walls of hewn stone, the tents themselves being formed of the same material.

CAMPHORA, or CAMPHIRE, a solid concrete substance extracted from the wood of the *laurus camphora*, is white, pellucid, unctuous to the touch, of a bitter aromatic taste, and smells like rosemary. As a medicine, it is useful in fevers, and all malignant distempers. From experiments on brutes, camphire is proved to be poisonous.

CAMUS, CHARLES STEPHEN LEWIS, a celebrated French mathematician, born at Cressey in Brie, August 25, 1699; died 1768, in the sixty-ninth year of his age.

CANAL, an artificial cavity in the earth, filled with water, to afford an easy, speedy, and cheap conveyance of goods, &c. in boats and vessels, from one part of a country to another.

---

* It was introduced into Russia by Peter the Great, who obtained the model of one, when he worked in Holland as a common ship-carpenter.

Numerous circumstances contribute to facilitate or retard operations in canal-making; as, the situation and character of the ground and country, the vicinity and connexion of rivers. But the great business is the construction of the Locks, or Basons, lined with walls of masonry, and built where the ground is hilly. The principle of a lock is this: Suppose a declivity of 10 feet in a length of 50 yards of ground. Then we must construct a bason, with a flood-gate, so that when filled with water from above, it may permit the vessel to pass on along the upper channel of the canal. A fall of 17 feet would require two locks; a fall of 26 feet, three locks, each having 8 feet 8 inches fall. All these operations proceed on the principle of continuing levels to given points, and by artificial means floating a boat some 8 feet perpendicularly, when we cannot proceed further with the level, in order that she may swim in another superior level, and *vice versa*.

The Form of Locks, should approach as nearly as possible to the figure of the boats that are to navigate them. The width must only exceed that of the boat by a space sufficient to work the gates. A rectangle is therefore the most natural figure, because it consumes the smallest quantity of water, is filled and emptied in the shortest time, and is constructed at the least expense.

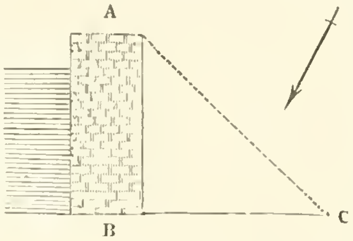
The Length, Depth, and Breadth of Locks, ought also to be regulated by the form of the boats, which are generally long and narrow, with flat bottoms. Narrow lock-gates are more easily worked than broad ones, and narrow boats are more easily drawn than those which are wider and shorter.

Reservoirs or Basins, must be resorted to wherever a double lockage is unavoidable, from undulations in the line of navigation. These basins should collect the flooded waters from an ample surface of country, and be so high as to enable all the water they contain to be drawn into the summit of the canal. They should contract towards their lower extremity, so as to require a comparatively short embankment or head, which should be placed upon a substantial foundation. Reservoirs must not leak. The dimensions of their embankments must be regulated by the nature of the materials.

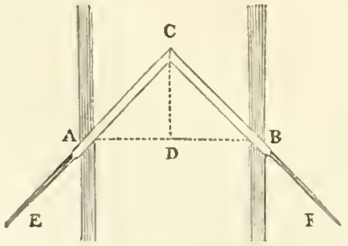
For the theory and practice of *Canal Cutting*, with *Plans of Locks* on the most celebrated canals, see Inland Navigation.

Canal *Embankment*.—Since the pressure of any fluid is proportional merely to the depth below the surface, the strain borne by a sluice on the sides of a canal must increase uniformly from the top to the bottom. The centre of pressure is hence not in the middle, but at one-third of the entire altitude. To this point, therefore, if more strength be wanted, the additional prop should be applied.

If water be confined in a canal or basin by a wall or embankment, the thickness of the dike must increase regularly in proportion to its depth. The adhesion of any materials, or their resistance to a horizontal thrust, may be estimated as a certain proportion of their weight, commonly the half or the third part. Let A B be the height of the wall, and make its density to three times that of water, as A B to BC, and join AC, which will represent the proper slope. If the dike be composed of stones or bricks, the base B C must be at least equal to the altitude A B; but if it consists of earth, B C should be one half more. When the embankment is formed of earth, its side must not be perpendicular; it should form an inclined plane, not exceeding 35 degrees, or *the angle of repose*, lest the softened parts should slide down; the outside, being more solid, may be steeper.



The Construction of Locks or Flood Gates.—In canal navigation, a boat is raised from a lower to a higher level by a series of locks, a portion of the water somewhat exceeding the length of the vessel being enclosed at the sides by walls, and at both ends by masonry, and opposite flood-gates. As soon as it passes these gates, they are shut behind it; and a small lateral or superior sluice being opened, the water rushes into the enclosure, and quickly mounts to the higher level, thus enabling the vessel again to proceed. A similar operation is performed at each successive lock. In descending the canal, the procedure is exactly reversed, the water contained in the series of enclosures being allowed to flow out, and thus lower by degrees the level of the boat.



The flood-gates are contrived to shut at a certain angle. If this angle be very acute, they sustain too great a pressure, and yet close feebly. Let A C and B C represent the flood-gates of a canal, which are opened by help of the extended arms A E and B F. When shut, the gate A C is pressed at right angles by the water, with a force as AC itself, which, from the principle of the lever, must exert a perpendicular effort at the end C, as the square of A C. The thrust thence produced in the direction A B will be as A C × C D, and will encounter an equal and opposite thrust from the gate B C. These two forces constitute the power which closes the gates. The force with which they are made to cohere, thus increasing with A C and C D, must augment rapidly when the angles B A C and A B C are enlarged, or their mutual inclination A C B becomes diminished.

If the angle A C B were very obtuse, those conjoined gates would, like a low roof, occasion a great thrust against the walls of the canal, or the centres of the gates at A and B. The thrust in the direction C A might be shown to be $\frac{AC^2 \times AD}{CD}$. It will hence be easy to determine the angle A C B, with the centres of the flood-gates which suffer the smallest strain; for A C being constant, $\frac{AC^2}{CD}$ must be a *minimum*. But this quantity is evidently the diameter of a circle circumscribing the triangle A C B; and since the least circle is that described about the point C, the angle A C B, at which the gates lock, should be a right angle.

CANCER, *the Crab*, ♋, is the first of the summer signs, which the sun enters, according to the fixed zodiac of the astronomers, on the 21st of June, introducing the first day of summer, and the longest day in the northern hemisphere,—the middle of day at the north pole, and the middle of night at the south pole. Agreeably to the moveable zodiac of nature, the sun enters this sign July the 19th. The sun, on June 21st, is at his greatest north declination, and is vertical to the tropic of Cancer. The earth, at this season, has entered Capricorn, and the sun is intermediate between the earth and the Celestial Crab. And on this account the north pole, which has now its greatest inclination to the sun, enjoys perpetual day. The tropic of Cancer is in the light from 5 in the morning till 7 at night; the parallel of London from a quarter before 4 till a quarter after 8, and the polar circle just touches the dark, so that the sun has only the lower half of his disk hid from the inhabitants on that circle, for a few minutes, about midnight. Thus do we account for summer in the northern regions of the earth.—The boundaries and contents of this constellation are: on the north by Lynx, east by Leo, south by Hydra, and west by Gemini. There are 83 stars in this sign, *viz.* seven of the 4th magnitude, and the remainder of inferior magnitudes. α Canceris, near the eastern extremities of the great southern claw, having 12° 31′ 6″ north declination, and 132° 9′ 20″ of right ascension, rises nearly E.N.E. at London, and rises and culminates as follows: Meridian Altitude, 51° 0′ 6″.

Month.	Rises.	Culm.	Month.	Rises.	Culm.
	ho. mi.	ho. mi.		ho. mi.	ho. mi.
Jan.	7 14 A.	2 0 M.	July	7 0 M.	2 15 A.
Feb.	4 50 A.	11 50 A.	Aug.	5 0 M.	12 10 A.
Mar.	3 10 A.	10 10 A.	Sept.	3 5 M.	10 10 M.
April	1 15 A.	8 15 A.	Oct.	1 15 M.	8 15 M
May	11 20 M.	6 30 A.	Nov.	11 25 A.	6 20 M.
June	9 7 M.	4 15 M.	Dec.	9 20 A.	4 20 M.

CANDY, or **SUGAR CANDY**, is sugar melted and crystallized six or seven times over, till it is rendered hard and transparent.

CANES VENATICI, the Hounds or Greyhounds, a northern constellation. These two dogs are farther distinguished by the names *Asterion* and *Chara*.

CANICULAR, the name formerly given to the constellation Canis Major; and the same was also sometimes applied to the star Sirius, whence the *Canicular Days*.

CANICULAR *Days*, or *Dog-Days*, denote properly a certain number of days which precede and follow the heliacal rising of Canicular, or the Dog-star, in the morning; which were formerly the days of the greatest heat. The ancients imagined that this star, rising as above, was the cause of the hot sultry weather common at that season, as well as of the distempers which usually followed them, and somewhat of a similar notion still prevails in many of the remote parts of this country, even to the present day. The dog-days were commonly reckoned at about forty; *viz.* twenty before, and twenty after the heliacal rising of Sirius; and in the almanacks, were usually accounted absolutely from this circumstance, which in consequence of the precession of the equinoxes brought them into the months of June and July, instead of July and August: an alteration, however, has been made in this respect within a few years; and they are now, without any regard to the rising of Sirius, accounted from July 3 to August 11; these being considered the hottest days of the year.

CANICULAR *Year*, denotes the Egyptian natural year; which was computed from one heliacal rising of Canicular to another.

CANIS MAJOR, *the Great Dog*, a constellation in the heavens, is fabled to have been one of Orion's hounds; the other was *Canis Minor;* for Orion, Boötes, and Sagittarius were denominated Hunters among the constellations: but some writers of ancient story tell us, that the sagacious Mæra, which discovered to Erigone the burial place of her murdered father Icarius, was changed into one of the celestial dogs. The true account of Canis Major, and which has obtained the credence of mankind, is, that it represents the Egyptian god Anubis. The people of Egypt judged of the swelling of the Nile by the rising of the brilliant in this constellation, and hence they represented it by the figure of a dog, this animal being the most watchful and faithful of the brute creation. The Dog Star, *Latrator Anubis*, is vertical on the 30th of June, when the Nile overflows. Indeed, Canis Major seems to have had the same relation to the Nile that Cerberus had to the sun; and Porphyry, who was well versed in the mythology of the ancients, says, Cerberus was described with three heads, in reference to the rising, the meridian altitude, and the setting of the sun. The triple bust of the Hindu deity exhibits to us in one compound figure an hieroglyphic of the solar god, having a perfect resemblance to Cerberus. At night, and in the west, the sun is *Vishnou;* he is *Brahma* in the east, and in the morning; from noon to evening he is *Seeva.*—The boundaries and contents of this constellation are: on the north by Monoceros, east and south by Argo Navis, and west by Columba Noachi and Lepus. In this constellation there are sixty-four stars, of which the brilliant *Sirius* is of the 1st magnitude, two of the 2d, four of the 3d, four of the 4th, &c. *Sirius* in size and colour resembles the planet Jupiter more than any of the other fixed stars, and has thence been supposed to be nearer our earth than Arcturus, Capella, Vega, Spica, or Aldebaran. The right ascension of Sirius for 1820 was 99° 18′ 10″; and the declination 16° 28′ 11″ south. It rises at London on the S. E. by E. ¼ E. point of the compass nearly; and rises and culminates as in the following table, for the 1st of every month: Meridian Altitude 22° 9′ 49″.

MONTH.	RISES. ho. mi.	CULM. ho. mi.	MONTH.	RISES. ho. mi.	CULM. ho. mi.
Jan.	7 28 A.	11 49 A.	July	7 18 M.	11 53 M.
Feb.	5 5 A.	9 37 A.	Aug.	5 10 M.	9 22 M.
Mar.	3 27 A.	7 48 A.	Sept.	3 24 M.	7 54 M.
April	1 26 A.	5 55 A.	Oct.	1 38 M.	6 6 M.
May	11 27 M.	4 4 A.	Nov.	11 40 A.	4 10 M.
June	9 27 M.	2 2 A.	Dec.	9 42 A.	2 6 M.

CANIS MINOR, *the Little Dog*, is said to be the type of one of the beagles in Orion's pack, or it is from the kennel of Boötes, or it is the sagacious cur *y'cleped* Mæra. The star Procyon, in Canis Minor, comes to the meridian about 50 minutes later than Sirius, but it rises to Egypt at the same time with the brilliant in the Great Dog, but 25 degrees further east. Now, whoever attends to the observations made by the ancients upon Sirius, must be satisfied that Procyon had its boundaries assigned from its being an attendant of the Great Dog, so famous in all that regarded the rising, overflowing, and decrease of the Nile. The Egyptians have introduced the astronomical symbols in pairs; thus we have two rivers, two serpents, two bears, two fishes, &c.; and there is very strong collateral evidence to prove that their whole territory was partitioned out agreeably to those symbols. With respect to the symbol before us, there seems little doubt that Canis Minor rising in conjunction with the Great Dog, but coming later to the meridian, as if assigning the other the point of honour, and then declining in the west above an hour later than its companion, was a fit emblem of that fidelity which *Latrator Anubis* was feigned to evince towards *Isis* and *Osiris*. One of the celestial dogs may thence have reference to the *arkite worship*, and the other to the *solar superstition.*—The boundaries and contents of Canis Minor are: on the north by Gemini, east by Hydra, and south and west by Monoceros. There are fourteen stars in this constellation, according to the Britannic Catalogue, *viz.* one of the 1st magnitude, one of the 2d, one of the 4th, &c. *α* Procyonis, of the 1st magnitude, in Canis Minor, rises at London, on the east by north point of the compass nearly; its declination north is 5° 46′, and its right ascension 112° 27′ 53″. It rises and culminates on the first day of each month, as follows: Meridian Altitude 44′ 15″.

MONTH.	RISES. ho. mi.	CULM. ho. mi.	MONTH.	RISES. ho. mi.	CULM. ho. mi.
Jan.	7 15 A.	12 41 A.	July	6 20 M.	12 50 M.
Feb.	5 2 A.	10 33 A.	Aug.	4 15 M.	10 42 M.
Mar.	3 15 A.	8 41 A.	Sept.	2 17 M.	8 46 M.
April	12 20 M.	6 47 A.	Oct.	0 30 M.	6 58 M.
May	10 15 M.	4 56 A.	Nov.	10 35 A.	5 2 M.
June	8 20 M.	2 58 A.	Dec.	8 27 A.	2 59 M.

The situation of *α* (Procyon) is easily found when it is above the horizon at night, for it always forms a triangle with Betelgeux, Rigel, and Sirius; and it comes to the meridian about four minutes after Castor, and about one minute before Pollux.

CANNON, a military engine for throwing ball, first used in the battle of Cressy, in 1346, by king Edward; or, mounted in battery on the decks of ships, to fire balls on other ships.

The principal parts of a cannon are, 1st. The breech, and its button or cascabel, called by seamen the pomelion. The breech is generally understood to be the solid metal from the bottom of the concave cylinder to the cascabel, which is the extremity of the cannon opposite to its muzzle. 2d. The trunnions, which project on each side like arms, and serve to support the cannon near the middle of its length, holding it almost in equilibrio. As the metal is thicker at the breech than towards the mouth, the trunnions are placed nearer to that end than the other. 3d. The bore or caliber is the interior or concave cylinder, wherein the powder and shot are lodged when the cannon is charged or loaded. The entrance of the bore is called the mouth or muzzle. The other parts are as follow: The length; the 1st reinforce; the 2d reinforce; the chase; the ventfield; the chase girdle; the breech mouldings; the swelling of the muzzle; the base ring and ogee; the vent astragal and fillets; the 1st reinforce ring and ogee; the 2d ditto, ditto; the chase astragal and fillets; the muzzle ditto, ditto; the muzzle mouldings; the swelling of the muzzle.

The diameter of the ball is always somewhat less than the bore of the piece, that it may be discharged with the greater ease, and not damage the piece by rubbing it too forcibly in its passage, and the difference between these diameters is called the windage of the cannon. The length of any cannon is always reckoned from the hind part of the base ring, or beginning of the cascabel, to the extremity of the muzzle. The second reinforce begins at the same circle where the first terminates, and the chase at the same circle where the second reinforce ends.

The first reinforce, therefore, includes the base ring, the ogee nearest thereto, the vent-field, the vent-astragal, and first reinforce ring. The second reinforce contains the ogee next to the first reinforce ring, and the second reinforce ring. The chase comprehends the ogee nearest to the second reinforce ring; the chase girdle and astragal, and the muzzle and astragal. The trunnions are always placed on the second reinforce, so that the breech part of the cannon may weigh something more than the muzzle part, to prevent the piece from starting up behind when it is fired.

A variety of experiments made with great care and accuracy, prove that the powder, when on fire, possesses at least 4000 times more space than when in grains. Therefore, if we suppose that the quantity of powder with which a cannon is charged, possesses one-fourth of a cubical foot in grain, it will, when on fire, occupy the space of about 1000 cubical feet. The same experiments evince also, that the powder, when inflamed, is dilated equally round its centre. One grain of powder fired in the centre of different concentric circles, round which grains of powder are placed, shall therefore set fire to all those grains at once. From this principle, it necessarily follows, that powder when fired in a cannon, makes at the same instant an equal effort on every part of the inside of the piece, in order to expand itself about its centre every way. But as the resistance from the sides of the piece turns the action of the powder so as to follow the direction of the bore of the cannon, when it presses upon the ball, so as to force it outwards, it presses also on the breech of the cannon, and this gives the piece a motion backwards, that is called the recoil, which is restrained by the breeching, and the convexity of the decks. The recoil in some degree diminishes the action of the powder upon the shot. But this cannot be avoided; for if the carriages were fixed so as not to give way to this motion, the action of the powder, or the effort that causes the recoil, would tear them to pieces in a very short time.

The metal of the cannon is not equally thick in all parts, but is in some measure proportioned to the force of the powder which it is to resist. At the breech, where the effort is strongest, the thickness of the metal is equal to the diameter ot the corresponding shot. At the first reinforce, when this begins to slacken, the thickness is somewhat less than at the breech; at the second, where the force is still further diminished, the thickness is more reduced than at the first; and by the same rule, the chase has less thickness than the second reinforce. The thickness of the chase gradually diminishes from the trunnions to the mouth of the piece; so that if a cannon was without a cascabel, trunnion, and mouldings, it would exactly resemble the frustum of a cone, or a cone deprived of the small end.

Cannons are charged by putting down into the bottom first a quantity of powder, one-third or one-half the weight of the ball. This is done with an instrument termed a ladle, which is a kind of cylindrical spoon, generally made of copper, and fixed to the end of a staff called its handle. Upon the powder is put in a wad of rope yarn, formed like a ball, which is pressed down upon the powder with an instrument called a rammer; upon this wad is put the ball or shot, and to secure it in its proper place, another wad is firmly pressed down upon it, which operation is called ramming home the wad and shot. The touch-hole of the piece is then filled with powder, from the upper part of which a little train is laid that communicates with it. The use of this train is to prevent the explosion of the powder from operating directly upon the instrument employed to fire the piece, which, in that case, might be forced out of the hand of the gunner.

In the modern pieces, a little gutter or channel is framed on the upper part of the breech, to prevent the train from being dispersed by the wind. This channel reaches from the touch-hole to the base ring.

The cannon being pointed to its object, or the place it is intended to strike, the train is fired, and the flame immediately conveyed to the powder in the touch-hole, by which it is further communicated to that in the piece. The powder being kindled, immediately expands, so as to occupy a much greater space than when in grains, and thus dilated, it makes an effort on every side to force itself out. The ball making less resistance than the sides of the piece, upon which the powder presses at the same time, is driven out by its whole effort, and acquires that violent motion which is well known to the world. After firing, there is a sponge used to clean the piece, and extinguish any sparks that may remain behind. In the land service, the handle of the sponge is a long wooden staff; but in ships of war, this handle, which usually contains the rammer at its other end, is a piece of rope well stiffened by spun-yarn, which is for this purpose firmly wound about it. By this convenience the rammer becomes flexible, so that the piece is charged within the ship, as the person who loads it may bend and accommodate the length of the rammer to the distance between the muzzle and the ship's side; being at the same time sheltered from the enemy's musketry, to which he would be exposed, in using a wooden rammer without the ship. To sponge a piece, therefore, is to introduce this instrument into the bore, and thrusting it home to the further end thereof, to clean the whole cavity.

The worm, of which there are different kinds, is used to draw the charge when necessary. The bit, or priming-iron, is a kind of large needle, whose lower end is formed into a gimblet, serving to clear the inside of the touch-hole, and render it fit to receive the prime. The lint-stock is a kind of staff, about three feet long, to the end of which a match is occasionally fastened to fire the piece.

The following is Mr. Robin's scheme for augmenting the force of the present sea-batteries, on this plain principle—that all ship-guns should be cast upon the model of the 32-pounders, measuring by the diameter of the respective bullet; so that for each pound of bullet there should be allowed one hundred and two-thirds of metal only. The advantages of this scheme will appear by the following comparison of the weight of the present pieces, with their weight proposed by this new fabric.

Pounders.	Weight now in Hundreds.	Weight by New Fabric.
24	48 to 46	40
18	41 to 39	30
12	34 to 31	20
9	29 to 26	15
6	34 to 18	10

Hence it appears that the 24-pounders will be eased of 6 or 8 cwt. of useless metal; and instead of guns of inferior caliber now used, much larger ones of the same weight may be borne, especially when it is remembered that this computation exceeds even the present proportion of the 32-pounders; so that from the above projected 18-pounders, for instance, 2 or 300 weight may be safely taken. The changes then proposed by the author are these:—

	Pounders.		Hundreds.		Pounders.		Hundreds.
For	6	of	24 and 18	New	12	of	20
	9		29 and 26		18		28
	12		34 and 31		24		40
	18		41 and 39				

The nine-pounders lately cast, being still lighter than what is here represented, they may, perhaps, be only transformed into 12-pounders; but this will be a very great addition of strength, and the 12-pounders thus borne, will be considerably lighter than the smallest nine-pounders now in use. The weight of the present three-pounders is not remembered exactly by the author, but he doubts not that they are heavier than the proposed six-pounders, and may therefore be changed for them. And the author believes, that one-fourth or one-fifth of the weight of the bullet in powder, if properly disposed, is abundantly sufficient for every species of ship's guns.

Boring CANNON. (See Pl. OIL MILL.)—Till within a few years, iron cannon were cast with a cylindrical cavity, nearly of the dimensions of the caliber of the piece, which was afterwards enlarged to the proper caliber by means of steel-cutters fixed into the dog-head of a boring bar-iron. Three equidistant side-cutters were requisite to preserve the caliber straight and cylindrical; and a single cutter was used at the end of the bar to smooth the breech of the piece. In boring cannon cast hollow, the piece was fixed upon a carriage that could be moved backwards and forwards in a direct line with the centre of a water-wheel; in this centre was fixed the boring-bar, of a sufficient length to reach up to the breech of the piece, or more properly to the further end of the caliber. The carriage with the piece being drawn backwards from the centre of the water-wheel to introduce the boring and finishing bars and cutters, it is then pressed forwards upon this bar by means of levers, weights, &c. and the water-wheel being set going, the bar and fullers are turned round, and clean out and smooth the caliber to its proper dimensions.

Experience at last pointed out many inconveniences arising from the method of casting guns *hollow*, and widening the calibers by boring bars; but chiefly, that all guns cast hollow became more or less spongy where they ought to have been most compact; and numberless cavities also were created round the cores, from stagnated air generated in them, which were too deep to be cut out by the boring. To remedy these defects, iron cannon as well as brass is now universally cast solid, by which means the column of metal is greatly enlarged, and the grain more compressed; and the contraction becomes in the heart of the column, and consequently is cut out by the perforation for the caliber.

Guns are bored out of the solid reversely from the hollow method. The piece A is placed upon two standards B B, by means of two journeys, turned round by machinery; the breech D being introduced into the central line of the wheel, with the muzzle towards the sliding carriage E, which is pressed forwards by a ratch F, and weights, in the same way as the gun carriage was in hollow-boring. Upon this sliding carriage is fixed, truly horizontal and central to the gun, the drill-bar G, to the end of which is fixed a carp's-tongue drill or cutter H; which, being pressed forward upon the piece whilst it is turning round, perforates the bore, which is afterwards finished with bars and cutters as the hollow guns were.

The machinery for boring of ordnance is sometimes put in motion by a steam-engine; and in this way, from 18 to 24 great guns have been boring at the same time; the borer in each piece being brought up to its proper place in the gun, by a lever and weights. In this method of bringing up the borer, the pressure may always be made equable, and the motion of the borer regular; but the disadvantage is, that without due attention, the borer may work up too far towards the breech, and the piece be spoiled.

"In the Royal Arsenal at Woolwich," says Dr. Gregory, "only one piece is bored at a time in the same mill: the gun to be bored lies with its axis parallel to the horizon, and in that position is turned round its axis by means of wheel-work, moved by one or more horses. The borer is laid, as above described, in the direction of the axis of the gun, and is incapable of motion in any direction except that of its length; and in this direction it is constantly moved by means of a small rack-wheel, kept in proper motion by two men, who thus make the point of the borer so to bear against the part of the gun that is boring, as to pierce and cut it. The outside of the gun is smoothed at the same time by men with instruments fit for the purpose, whilst it turns round, so that the bore may be exactly in the centre of the metal. In this way the boring is performed with great nicety, the guns scarcely ever failing in the examination. But in these mills the horses work to great disadvantage, the diameters of the walks in which they move being far too small." *See* GUN, POWDER, GUNNERY.

CANNONADE, the application of artillery to the purposes of war, directing the shot against some remote object, as a ship, a fortress, &c. which it is designed to destroy or capture. In the marine, a large vessel may be considered as a combination of floating batteries, and hence, her efforts must be greatly superior to those of a fortress on land; but this is not always the case, for on some particular occasions her situation may be extremely dangerous, and her cannonading ineffectual. There are several circumstances in which her superiority consists, *viz.* the power of bringing her different batteries to converge to one point; of shifting the line of her attack so as to do the greatest possible execution against the enemy, or to lie where she will be the least exposed to his shot; and chiefly because, by employing a much greater number of cannon against a fort than it can possibly return, the impression of her artillery against stone walls soon becomes decisive and irresistible. Besides these advantages in the attack, she is also greatly superior in point of defence; because the cannon shot passing with rapidity through her sides, seldom do any execution out of the line of their flight, or occasion much mischief by their splinters; whereas, they very soon shatter and destroy the faces of a parapet, and produce incredible havock amongst the men by the fragments of the stones, &c. A ship may also retreat when she finds it too dangerous to remain longer exposed to the enemy's fire, or when her own fire cannot produce the desired effect. Finally, the fluctuating situation of a ship, and of the element on which she rests, render the efforts of shells very uncertain, and altogether destroys the effect of the ricoshet or rolling and bounding shot, whose execution is so pernicious and destructive to a fortress in land engagements; both of which, however, a ship of war may apply with great success. On the contrary, the chief inconvenience to which she is exposed, is, that the low-laid cannon in a fort, near the brink of the sea, may strike her repeatedly on or under the surface of the water, so as to sink her before her cannonade can have any considerable efficacy.

CANOE, a sort of Indian boat, or vessel, formed of the trunk of a tree hollowed, and sometimes of several pieces of the bark fastened together; they are used on various occasions, as fishing, passage, trade, &c. and are of several sizes, according to the different uses for which they are designed in different countries. They are generally rowed with paddles, instead of oars, which are pieces of light wood, nearly resembling a corn shovel, and instead of moving the paddle horizontally like an oar, they row perpendicularly; the small ones are very narrow, having only room for one person in breadth, and eight or ten lengthways. They very easily carry sail, unless when going before the wind, and their sails are made of a sort of rushes or silk grass; they seldom have any rudder, the want of which is supplied by a dexterous management of the hind oars. The Indians who navigate them are very expert in rowing uniformly, and in balancing them properly with their bodies, which would be difficult for a stranger to do, however well accustomed soever to the conducting of our boats, on account of the extreme lightness of the canoes, and their aptness to be overturned. The Negroes in Guinea, and even many in the East Indies, use them. The American Indians, when they are necessitated to land on account of a waterfall or other occasion, carry their canoes on their heads or shoulders, till they arrive at some place where they may again be launched. The canoe of the Esquimaux Indians in Labrador has a light wooden frame, and the shell, instead of a plank, is made with seal skins sewed together, which are not only extended round the bottom and sides, but likewise over the top, forming a complete deck, and having only one opening conveniently framed, and situated to admit the Indian into his seat. A flat hoop is fitted to this hole rising about four inches, to which the surrounding skin is sewed. The Indian's calf-skin jacket being of a proper length, he can occasionally bind the skirt of it round the outside of this hoop, by which means he keeps the canoe free from water, and is enabled to pursue his game far from land, and in stormy seas. His paddle is about 10 feet long, light, and flat at each end, with which he both rows and steers with great velocity and exactness.

CANON, in Arithmetic, Geometry, &c. a general rule for resolving all cases of the same kind: this word is now seldom used; we say instead of it, method or formula.

CANT TIMBERS, those timbers which are situated at the two ends of a ship. They derive their name from being canted or raised obliquely from the keel, in contradistinction to those whose planes are perpendicular to it. The upper ends of those on the bow or fore part of the ship are inclined to the stem, as those in the after or hind part incline to the stern-post above.

CANTATA, in Music, a song or composition intermixed with recitatives, airs, and different movements, chiefly intended for a single voice.

CANVASS, a strong kind of cloth, of which the sails are made. Among Painters, canvass is the cloth on which they usually draw their pictures, having first stretched it in a frame of deal wood.

CAOUTCHOUC, elastic resin, or Indian rubber, a substance produced from an American tree, has been already explained. This substance oozes out of the trees by incisions made in them, and has the appearance of milk, and it is thickened merely by exposure to the air.

CAOUTCHOUC *Gum* is thus made:—Take one pound of spirit of turpentine, and one pound of the gum, cut into small pieces. (A knife dipped in cold water cuts this elastic stuff easily.) Pour the turpentine into a long-necked matrass, or fire-proof bottle, which must be placed in a sand bath; throw in the gum, bit by bit, till it all dissolves. Add now a pint of nut or linseed oil, or oil of poppies; then let the whole boil for a quarter of an hour, and the preparation is finished. This is an excellent but expensive varnish for air-balloons.

CAP, a strong thick block of wood, having two large holes through it, the one square, the other round, used to confine two masts together, when one is erected at the head of the other, in order to lengthen it. The principal caps of a ship are those of the lower masts, which are fitted with a strong eye-bolt on each side, wherein to hook the block by which the topmast is drawn up through the cap. The breadth of all the caps is equal to twice the diameter of the topmast, and the length to twice the breadth. The thickness of the main and forecaps is half the diameter of their breadths; the mizencap three-sevenths, and the topmast caps two-fifths of their respective breadths. In the same manner as the topmast slides up through the cap of the lower mast, the top-gallant-mast slides up through the cap of the topmasts.

CAPILLARY ACTION. The suspension of a slender column of water in the interior ring of a glass tube, is the popular explanation of capillary action, or attraction.

CAPILLARY *Tubes.* One of the most singular phenomena of these tubes is, that if you take several of them of different sizes, open at both ends, and immerse them a little way into water, or any other fluid, it will immediately rise in the tubes to a considerable height above the surface of that into which they are immersed; these heights varying nearly in a reciprocal proportion of the diameters; the greatest heights, according to Dr. Hook, being about 21 inches. The heights, however, are not the same for all fluids, some standing considerably higher or lower than others: and with regard to quicksilver, it does not rise in their tubes at all, but, on the contrary, stands lower in the tube than in the vessel into which the tube is immersed, and that so much the more as the diameter is smaller. Another phenomenon of these tubes is, that such of them as will naturally discharge water only by drops, when electrified yields it in a perpetual stream. Various hypotheses have been advanced to account for the ascent of fluids in capillary tubes; some attributing it to the attraction of the glass upon the upper surface of the fluid, others again, to the diminished pressure of the air on the fluids in the tube, &c. The cause of the phenomenon is satisfactorily accounted for thus: It is a fundamental property of fluids, that any force impressed in one direction may be propagated equally in every direction. The tendency of the fluid, then, to approach the glass, will occasion it to spread over the internal cavity of the tube, and consequently to mount upwards.

Capillary action is not confined to glass tubes, but is exerted among all substances perforated by pores, or subdivided by fissures or interstices. Hence, the excretory vascular systems of plants and animals; the ascent of humidity through rocks, earth, &c.; the lymph or perspiration exuded by the pores of the human skin, the leaves of trees, plants, and grasses—pores that exceed not the ten-thousandth part of an inch: and while plants retain their vegetating principle, the humidity they draw from the earth by means of their roots, is constantly exhaled into the atmosphere, and as constantly supplied by the ascent of sap from the roots.

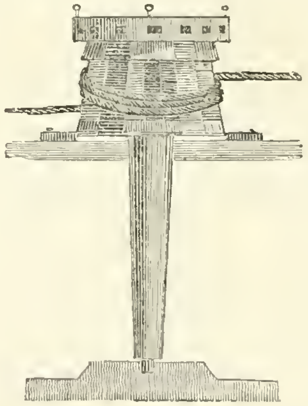
CAPRA, the name of a small Northern Constellation, consisting of three stars.

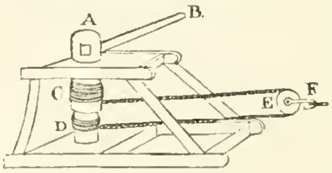
CAPRICORN, *the Goat*, a southern constellation, and the tenth sign of the zodiac, denoted by the character ♑, being intended for the representation of the goat's horns. It is the first of the winter, and the fourth of the southern signs, according to the fixed and intellectual zodiac; and the sun enters it on the 21st of December, which is the time of the winter solstice, when the earth makes the transit from Gemini to Cancer. But the visible and moveable zodiac places this sign in the station of Aquarius, and the sun enters it about the 16th of January. At the period of the winter solstice, the sun being vertical to the tropic of Capricorn, the southern hemisphere enjoys the same light, &c. which the northern hemisphere enjoyed on the 21st of June, when the sun was vertical to the tropic of Cancer. It is then the middle of day at the south pole, and the middle of night at the north pole.—The boundaries and contents of Capricorn are: on the north and east of Antinous and Aquarius, on the south by Piscis Australis, and on the west by Sagittarius. It contains 51 stars, three of which are of the 3d magnitude, three of the 4th, &c. The following table shews the time when α, a star of the third magnitude, in the Goat's forehead, rises and culminates for the first day of each month in the year. This star rises nearly on the E. S. E. ¼ E. point of the horizon, at London; its right ascension is 302° 0′ 51″, and its declination 13° 5′ 39″ south: Meridian Altitude 25° 23′ 21″.

MONTH.	RISES. ho. mi.	CULM. ho. mi.	MONTH.	RISES. ho. mi.	CULM. ho. mi.
Jan.	8 30 M.	1 25 A.	July	8 37 A.	1 30 M.
Feb.	6 14 M.	11 10 M.	Aug.	6 40 A.	11 25 A.
Mar.	4 25 M.	9 20 M.	Sept.	4 45 A.	9 30 A.
April	2 30 M.	7 20 M.	Oct.	2 58 A.	7 40 A.
May	12 45 M.	5 30 M.	Nov.	1 0 A.	5 45 A.
June	10 35 A.	3 28 M.	Dec.	10 45 M.	3 45 A.

Tropic of CAPRICORN, a small circle of the sphere parallel to the equinoctial, passing through the beginning of Capricorn, or the winter solstice, or point of the sun's greatest southern declination.

CAPRIOLES, in the Manage, leaps which a horse takes in the same place without advancing, in such a manner, that when he is at the height of the leap, he jerks out with his hinder legs even and near. The common name of this exercise is, among dragoons, *the pillared horse*, because the animal, to work well at caprioles, is put between two pillars, and taught to raise first his fore quarters, and then his hind quarters, while his fore ones are yet in the air.

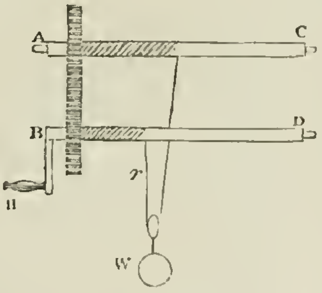




CAPSTAN, or CAPSTERN, a great piece of timber, in the shape of a cone, usually placed behind the windlass of a ship, to weigh anchors, hoist up or strike down topmasts, strain ropes, or heave any heavy bulky thing on board of a ship, as in the upper figure.

The advantages of simplifying machinery are well exemplified in the second capstan, which unites great strength and simplicity. It is represented in the lower figure, where A D is a compound barrel composed of two cylinders of different radii. The rope D E C is fixed at the extremity of the cylinder D; and after passing over the pulley E, which is attached to the load by means of the hook F, it is coiled round the other cylinder D, and fixed at its upper end. The capstan bar A B urges the compound barrel C D about its axis, so that while the rope coils round the cylinder D it unwinds itself from the cylinder C. Let us suppose, that the diameter of the part D of the barrel is 21 inches, while the diameter of the part C is only 20 inches, and let the pulley E be 20 inches in diameter. When the barrel A D, therefore, has performed one complete revolution by the pressure exerted at B, 63 inches of rope, equal to the circumference of the cylinder, will be gathered upon the cylinder D, and 60 inches will be unwound from the cylinder C. The quantity of wound rope, therefore, exceeds the quantity that is unwound by 63 — 60 = 3 inches, the difference of their respective perimeters; and the half of this quantity, or 1½ inches, will be the space through which the load or pulley E moves by one turn of the bar. If a simple capstan of the same dimensions had been employed, the length of rope coiled round the barrel would have been 60 inches; and the space described by the pulley, or load to be overcome, would have been 30 inches. Now, as the power is to the weight as the velocity of the weight is to the velocity of the power, and as the velocity of the power is the same in both capstans, the weights which they will raise will be as $1\frac{1}{2}$ to 30. If it be wished to double the power of the machine, we have only to cover the cylinder C with lathes a quarter of an inch thick, so that the difference between the radii of each cylinder may be half as little as before; for it is obvious that the power of the capstan increases as the difference between the radii of the cylinders is diminished. As we increase the power, therefore, we increase the strength of our machine, while all other engines are proportionably enfeebled by an augmentation of power. Were we, for example, to increase the power of the common capstan, we must diminish the barrel in the same proportion, supposing the bar A B not to admit of being lengthened, which will not only diminish its strength, but destroy much of its power by the additional flexure of the rope.—This capstan may be easily converted into a crane, by giving the compound barrel a horizontal position, and substituting a winch instead of the bar A B. The superiority of such a crane above the common ones does not require to be pointed out; but it has this additional advantage, that it allows the weight to stop at any part of its progress, without the aid of a ratchet wheel and catch, because the two parts of the rope pull on the contrary sides of the barrel. The rope indeed which coils round the larger part of the barrel acts with a larger lever, and consequently with greater force, than the other; but as this excess of force is not sufficient to overcome the friction of the machine, the weight will remain stationary in any part of its path.

The principle on which the preceding capstan is constructed, might be applied with great advantage when two separate axles A C, B D are driven by means of the winch H and the wheels B and A, as in the annexed figure. It is evident, that when the winch is turned round in one direction, the rope *r* is unwound from the axle B D; the wheel B drives the wheel A, so that the axle A C moves in a direction opposite to that of B D, and the rope is coiled round the axle A C. If the wheels A, B, are of the same diameter and the same number of teeth, the weight W will be stationary, as the rope wound about one axle will be always equal to what is unwound from the other. If the wheels have different diameters, or different numbers of teeth, the quantity of rope wound round the one axle will exceed what is unwound from the other, and the weight will be raised.



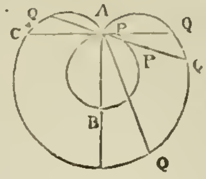
CAPUT Draconis, *the Dragon's Head*, a name given by some to the star *a*, Draconis, in the head of that constellation.

CARDAN, Jerom, a celebrated mathematician, physician, and astrologer of the sixteenth century, born in Italy Sept. 24, 1501, and died at Rome in Sept. 1575. As an astrologer, he was invited to England in order to cast the nativity of Edw. V. as he had already done that of his own; which latter not being precisely correct as to the time of his death, he is said to have starved himself for the honour of the science; *viz.* that his living might not discredit his art. Hudibras alludes to Cardan's pretended astrological skill in the following lines:—

> " Cardan believes great states depend
> Upon the tip of the Bear's tail's end;
> And as she wisks it t'wards the sun,
> Strews mighty empires up and down."

CARDINAL Points, in Geography and Navigation, the four principal points of the compass; *viz.* east, west, north, and south. The term is derived from *cardo*, a *hinge*, being that on which all the others turn or depend.

Cardinal *Signs*, are those at the four quarters, or the equinoxes and solstices; *viz.* the signs Aries, Libra, Cancer, and Capricorn. *Cardinal Winds*, those that blow from the cardinal points.



CARDIOIDE, (see the annexed figure,) the name of a curve so denominated by Castilliani, from its resemblance to a heart, καρδια: the construction of which is as follows:—Through one extremity A, of the diameter A B, of the circle A P B, draw a number of lines A P Q, cutting the circle in P P, &c. upon the set off P Q, equal to the diameter A B; then the curve passing through all the points Q, Q, &c. is termed the Cardioide. From this generation of the curve, is readily reduced its principal properties; *viz.* that every where .... $PQ = AB$

$$CQ \text{ or } QQ = Aa = 2AB$$
$$AQ = AB \pm AP$$

P always bisects Q Q.

CAREENING, the operation of heaving a ship down on one side, by the application of a strong purchase to her masts, which are properly supported for the occasion, to prevent their breaking with so great a strain; by which means one side of the bottom, being elevated above the surface of the water, may be cleansed or repaired. When a ship is laid on a careen every thing is taken out of her; but this operation is now nearly superseded by sheathing the ships with copper, whereby they keep a clean bottom for several years. A ship is also said to careen, when she inclines to one side at sea by a press of sail.

CARLINGS, short pieces of timber ranging fore and aft from one deck beam to another, into which their ends are mortised; they are used to sustain and fortify the smaller beams of the ship.

CARMINATIVES, Medicines used in colics, or other flatulent disorders, to dispel wind.

CARMINE. *See* Colour Making.

CARNATION, or Clove Pink, an agreeable flower, valued for its pleasant flavour and lovely leaves. It is said the flowers of this plant, reduced to a decoction, have cured many malignant fevers, &c.

CARNELIAN, in Natural History, a precious stone, red, yellow, or white, usually brought from the East Indies.

CAROTIDS, in Anatomy, two arteries of the neck, which convey the blood from the aorto to the brain; one called the right, and the other the left carotid.

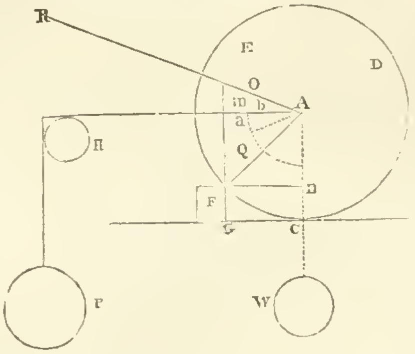
CARPENTER, a person who practises carpentry.

Carpenter of a ship, is an officer appointed to examine and keep in order the frame of the ship, together with her masts, yards, boats, and all other wooden machinery, likewise the stores committed to him by indenture from the surveyor of the dock yard. It is the carpenter's duty in particular, to keep the ship tight, for which purpose he ought frequently to review the decks and sides, and to caulk them when it is found necessary. In the time of battle, he is to examine up and down with all possible attention in the lower apartments of the ship, to stop any holes that may be made in the sides by shot, with wooden plugs, provided of several sizes for that purpose.

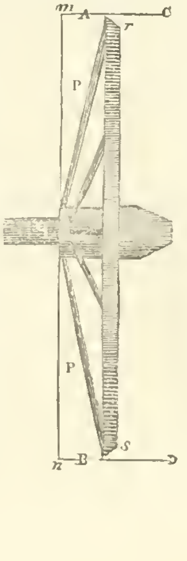
CARPENTRY, the art of building, framing, &c. *See* Joiner.

CARRIAGE of a Gun, is a strong frame of wood fixed on four solid wheels, or trucks, on which the cannon is placed: its chief parts are as follow:—1. The sides or cheeks; 2. the axletrees; 3. the trucks or wheels; 4. the transom; 5. the sole or bottom; 6. the bed; 7. the quoin. These are all of wood. 8. the cap-squares, or clamps; 9. the eye-bolts; 10. joint bolts; 11. the transom bolt; 12. the bed bolt; 13. hind axletree bolts; 14. the breeching bolts; 15. loops, or eye-bolts, to which the gun tackle are hooked; all of iron.

The Construction of Wheel Carriages is one of the most important branches of mechanical science, whether we consider their general use, or the numerous lives which are daily risked in travelling by this mode of conveyance. We will, therefore, in the first place, direct our readers' attention to the wheels of these vehicles. Every wheeled carriage consists of two or more wheels, generally four: but the fore wheels of our waggons are unaccountably small, and it is not uncommon to see carts moving upon wheels scarcely two feet diameter. We know that the convenience of turning is urged as the reason for diminishing these wheels, and we allow, that much address is requisite in the crowded and narrow lanes and courts of London, to turn unwieldy waggons, drawn by four huge horses. The disadvantages of small wheels will be obvious from this: Suppose C D E (as in the annexed figure,) a wheel, and F G an obstacle over which it is to be moved by a force P, acting in the direction A H; join A F, and draw Fm, Fn, perpendicular to C A and A H. The weight D of the wheel is evidently the weight to be raised, and may be represented by W acting at the point A in the vertical direction A C. We may now consider A F as a lever, whose fulcrum is F, and there will be an equilibrium when the force P is to the force W, as the perpendicular Fn is to the perpendicular Fm. And since Fm represents the mechanical energy of the power P to turn the wheel round F, it is obvious, that when F G is equal to the radius of the wheel, (as in this case it is only 12 inches,) the weight P, however great, has no power to move it over the obstacle, for when F G is equal to A C, Fm will vanish, that is, the obstacle being as high as the axletree of the wheel, it could never surmount it. In other words, Fm is now equal to O, which, if multiplied by P, no matter what the weight of P may be, the product is O. How very difficult then must it be for the best horses to tug an unwieldy waggon with fore wheels only 14 inches in radius. Hence, since the power of a wheel to overcome stones, rubbish, and all manner of resistances in the road, increases with its *diameter*, the advantages of large wheels for overcoming such resistances must be apparent. But there are some circumstances, which, independent of their weight and expense, prescribe limits to the size of wheels. A wheel should never exceed 4½ feet diameter, that is, the height of a horse's shoulder where the traces are fixed to the collar.



With respect to the shape of the wheels, every mechanic would place the spokes perpendicular to the axletree, if he were not prejudiced, by apprenticeship, to the pretended advantages of concave or dishing wheels, or those which have inclined spokes, as in the annexed figure, P A, P B, and conical rims Ar and Bs. It is alleged, this wheel renders the carriage less liable to be overturned, by extending the base; that it is stronger; that it hinders the fellies from rubbing against the sides of the cart, &c. &c. But the concave dishing wheel is more expensive than the other, more injurious to the roads, more liable to be broken by accidents, and less durable than the wheel with spokes perpendicular to the naves. Look at the figure, and you will see that the whole of the pressure which the wheel A B sustains, is exerted along the inclined spoke, Ps therefore acts obliquely upon the level ground nD, whether the rims with their tire irons are conical or cylindrical. But when the spokes are perpendicular to the nave, as pn, and when the rims mA, nB, are cylindrical, and parallel to the ground, the weight sustained by the wheel acts perpendicularly upon the road, and whatever shocks it may receive from resistances, fall upon its strongest position, where it is in no danger of giving way to the strain.



The Position of Wheels.—All wheels should revolve on perfectly straight axletrees, and be themselves perfectly parallel or perpendicular to the road. By this method there is the least stress in all given cases on the linch-pin, the axles, the spokes, and rim; and the friction less than in the conic wheels, which partly roll and partly drag.

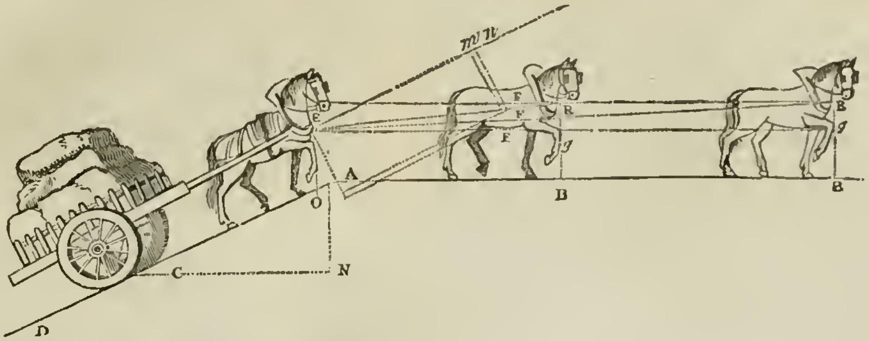
On the Line of Traction, and the Method by which Horses exert their Strength.—In all four-footed animals, the hinder feet become the fulcrum of the lever by which their weight acts against the load; and when the animals pull hard, they depress their chest, and thus increase the lever of their weight, and diminish the lever by which the load resists their efforts; for it is a general law, that animals draw by their weight, and not by the force of their muscles. So that when a horse is employed in drawing, his effort will depend, in some measure, both upon his own weight and that which he carries on his back.

Indeed it is highly useful to load the back of a drawing horse to a certain extent; though this, on a slight consideration, might be thought to augment unnecessarily the fatigue of the animal: but it must be considered, that the mass with which the horse is charged vertically is added in part to the effort which he makes in the direction of traction, and thus dispenses with the necessity of his inclining so much forward as he must otherwise do; and may, therefore, under this point of view, relieve the draught more than to compensate for the additional fatigue occasioned by the vertical pressure. Carmen, and waggoners in general, are well aware of this, and are commonly very careful to dispose of the load in such a manner that the shafts shall throw a due proportion of the weight on the back of the shaft horse.

The best disposition of the traces during the time a horse is drawing, is to be perpendicular to the position of the collar upon his breast and shoulders: when the horse stands at ease, this position of the traces is rather inclined upwards from the direction of the road; but when he leans forward to draw the load, the traces should then become nearly parallel to the plane over which the carriage is to be drawn; or, if he be employed in drawing a sledge, or any thing without wheels, the inclination of the traces to the road, supposing it to be horizontal, should be about 18½°.

From the preceding observations, it will be easy in most cases to adapt the size of the wheels to that of the animal which is to draw in the shafts, so that when he leans forward to his work, the traces may be nearly parallel to the road, whether that road be horizontal or not; always recollecting, that, if there be any variation from the parallel position, it must be rather inclining upwards than downwards; as the former will somewhat diminish the friction, while the latter, instead of raising the wheels from any hollow into which they may fall, will tend to draw them down lower, and much increase the labour of the animal.

When several horses are harnessed one before another, so that they may all draw at the same load, and the slope on which they are drawing changes, as from D A to A B, (see the engraving in the next page,) the effort of the horse which draws along the road A B is decomposed into two parts, of which one tends to pull up the load, the other to pull *down* the horse which is in the shafts and is drawing along the slope D A. This latter composant is always greater as the traces of the foremost horse are the longer. From the point E where the traces are fastened to the horse next the load, draw E R to the same point in the second horse R, and let R' be another position of the second horse; it is required to find the difference of effect that will be produced by placing the second horse at R or at R', or the comparative advantages of short and long traces. From R', the point where the traces are fixed, draw $R'F'E$; and from E draw Emn parallel to the declivity D A. Take $EF = EF'$ to represent the power of the horse in the direction of the traces, which will be the same whether he is yoked at R or at R'; draw E A perpendicular to D A, Fn, $F'm$ parallel to E A, and $F\phi$, $F'f$ parallel to En. Then since the second horse when at R pulls with a force represented by F E, in the direction F E, we may resolve this force into the two forces En, $E\phi$, one of which En is solely employed in dragging the cart up the inclined plane D A, while the other $E\phi$ is solely employed in pressing the first horse E to the ground. Let the horse be now removed from R to R′, the direction of the traces becomes R F′E, and F′E = F E is the power exerted by the horse at R′, and the direction in which it is exerted. But this force is equivalent to the forces E *m*, E *f*, the first of which acts directly against the load, while the other presses the horse against the ground. Hence we see the disadvantages of long traces, for the force which draws the load when the horse is at R′ is to the force when the horse is at R, as E *m* to E *n*, and the forces which press the horse upon the ground as E *f* to E φ, ...



...or as F′*m* to F *n*. Now $E\phi = Fn = FE \times \sin.\, nEF$; hence $F\phi = FE \times \sin.\, (nEg' - FEg')$ ($g'E$ being parallel to A B′) and $En = EF \times \cos.\, (nEg' - FEg')$. In like manner we have $Ef = FE \times \sin.\, (nEg' - F'Eg')$, and $Em = EF \times \cos.\, (nEg' - F'Eg')$. Now $\sin.\, FEg' = \sin.\, FEg = \frac{Rg}{ER}$, and $\sin.\, FEg' = \frac{R'g'}{ER'} = \frac{Rg}{ER'}$; but $Rg = R'g' = BR - EQ = BR - BR \times \cos.\, nEg' = BR \times (1 - \cos.\, nEg)$. By substituting this value in the equations which contain the values of E φ, E *n*, E *f*, E *m*, and considering that the angles FEg', $F'Eg'$, are always so small that their arcs differ very little from their sines, we have

$$FEg = \frac{BR \times \overline{1 - \cos.\, nEg}}{ER}, \text{ and } F'E'g' = \frac{BR \times \overline{1 - \cos.\, nEg}}{ER'}.$$

By substituting these values in the preceding equations, we have

$$E\phi = EF \times \sin.\, (nEg - \frac{BR \times \overline{1 - \cos.\, nEg}}{ER}.$$

$$Efn = EF \times \sin.\, (nEg - \frac{BR \times \overline{1 - \cos.\, nEg}}{ER'},$$

$$En = EF \times \cos.\, (nEg - \frac{BR \times \overline{1 - \cos.\, nEg}}{ER},$$

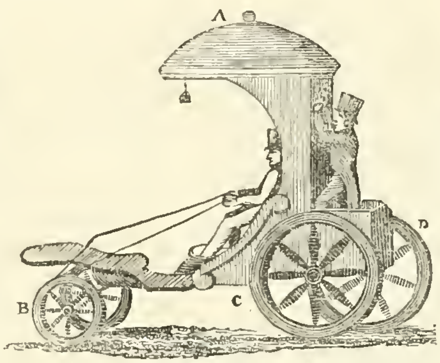
$$Em = EF \times \cos.\, (nEg - \frac{BR \times \overline{1 - \cos.\, nEg}}{ER'}.$$

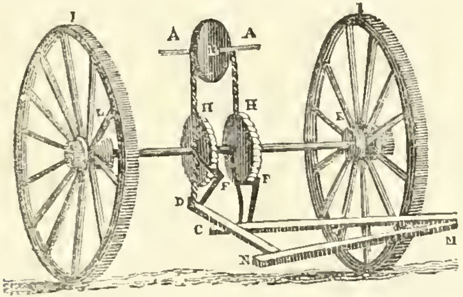
Suppose A B horizontal, the ascent D C A, that for every 6 feet, as C N in a horizontal plane, the vertical rise N A should be one foot; this slope is too steep for any common road, but may sometimes be met with in ascents from stone quarries, gravel pits, &c. In this case, the angle *n* E *g* will be nearly 9° 28′, which, expressed in decimal parts of the radius, gives sine 0·16522, and cos. *n* E *g* = 0·98638. Then if E F = 200 lbs. B R = 3½ feet, E R = 8 feet, E R′ = 12 feet. Then shall we have,

$$(1) \ldots\ldots Fq = 200 \sin\, (0{\cdot}16522 - \tfrac{3{\cdot}5\,(1 - 0{\cdot}98638)}{8})$$
$$= 200 \sin.\, 9^\circ\, 7'\, 29'' = 31{\cdot}716 \text{ lbs.}$$
$$(2) \ldots\ldots F'q' = 200 \sin.\, (0{\cdot}16522 - \tfrac{3{\cdot}5\,(1 - 0{\cdot}98638)}{12})$$
$$= 200 \sin.\, 9^\circ\, 14'\, 29'' = 32{\cdot}25 \text{ lbs.}$$
$$(3) \ldots\ldots Eq = 200 \cos.\, 9^\circ\, 7'\, 29'' = 177{\cdot}47 \text{ lbs.}$$
$$(4) \ldots\ldots Eq = 200 \cos.\, 9^\circ\, 14'\, 29'' = 197{\cdot}404 \text{ lbs.}$$

Hence it appears, that the horse whose breast is at E is pulled downwards by the other horse, with a force equivalent to about 32 lbs: this weight is small for a horse that is not fatigued; but we should consider, that when drawing up a steep road the animal's strength is much weakened, so that it may be obliged to yield to a very small effort. A lengthening of four feet to a trace of eight feet, will produce an augmentation of 32·25 — 31·716 = 0·534 lbs. in the effort which tends to pull the shaft horse down, and a diminution of 197·47 — 197·404 = 0·066 lbs. in the effort which raises the load up the hill. These quantities are not considerable; but it appeared desirable to explain the method of ascertaining their magnitude. And it may be added, that when a horse pulls for only a short time, as a few minutes, he will often exert a force equivalent to 500 or 600 lbs.: in which case, the tendency to pull down a shaft horse rising a hill would be thrice as much as we have stated it above; a force against which no horse could stand in such a disadvantageous position.

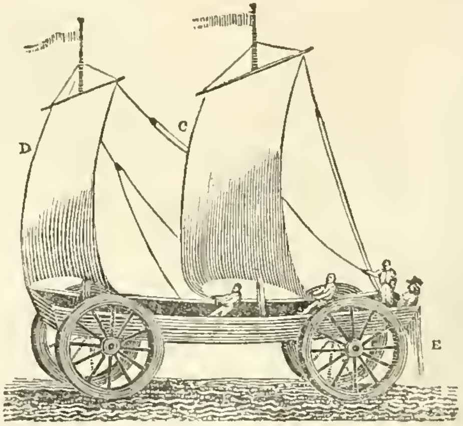
On the Position of the Centre of Gravity, and the manner of disposing the Load.—If the axletree of a two-wheeled carriage pass through the centre of gravity of the load, the carriage will be in equilibrio in every position in which it can be placed with respect to the axletree; and in going up and down hill the whole load will be sustained by the wheels, and will have no tendency either to press the horse to the ground, or to raise him from it. But if the centre of gravity is above the axletree, as it must necessarily be, according to the present construction of wheel-carriages, a great part of the load will be thrown on the back of the horses from the wheels when going down a steep road, and thus tend to accelerate the motion of the carriage which the animal is striving to prevent; while, in ascending steep roads, a part of the load will be thrown behind the wheels, and tend to raise the horse from the ground, when there is the greatest necessity for some weight on his back to enable him to fix his feet in the earth, and overcome the great resistance which is occasioned by the steepness of the road. On the contrary, if the centre of gravity is below the axle, the horse will be pressed to the ground in going up hill, and lifted from it when going down. In all these cases, therefore, where the centre of gravity is either on the axletree, or directly above it or below, the horse will bear no part of the load on level ground: in some instances he will be lifted from the ground, when there is the greatest necessity for his being pressed to it, and he will sometimes bear a great proportion of the load, when he should rather be relieved from it. The only way of remedying these evils, is, to assign such a position in the centre of gravity, that the horse may bear some portion of the weight when he must exert great force against the load, that is, in level ground, and when he is ascending steep roads; for no animal can pull with its greatest effort, unless it is enabled to use its feet as levers upon the ground as a prop or fulcrum. This may be effected in the following manner:—Let C D E (last figure but two) be the wheel of a cart, A H one of the shafts, H that part of the shaft by which the cart is suspended over the horse's back, A the axletree; then if the cart and the load together weigh 400 lbs, if the distance A H be 8 feet, and if the horse should bear 50 lbs of the weight, then *b* A should be one foot, which being one-eighth of A H, will make the pressure upon H exactly 50 lbs, for $50 \times 8 = 400$, the whole load. If the road slopes 4 inches in a foot, *b* Q must be 4 inches, or the angle *b* A Q should be equal to the inclination of the road; for then the point Q will rise to *a m* when ascending such a road, and will press with its greatest force on R the back of the horse. In a word, the centre of gravity Q is placed in a point equidistant from the two wheels, but before the line of traction A H, and before the axletree—the horse will bear a certain weight on level ground, a greater when going up hill, and has more occasion for it, and less weight, when going down hill, and does not require to be pressed to the ground. When carts are not made in this manner, we may, in some measure, obtain the same result by judiciously loading them. In a cart loaded with homogeneous materials, as sand, lime, &c. let us suppose the centre of gravity is at O, we should, with another load of heterogeneous materials, or bodies of different weights, place the heaviest at the bottom and nearest the front, which would lower the point *a*; bring it further forward, and nearer its proper position Q, where part of the load suspended before the centre of gravity would still come nearer Q; but then the poor horse is very injudiciously burdened.





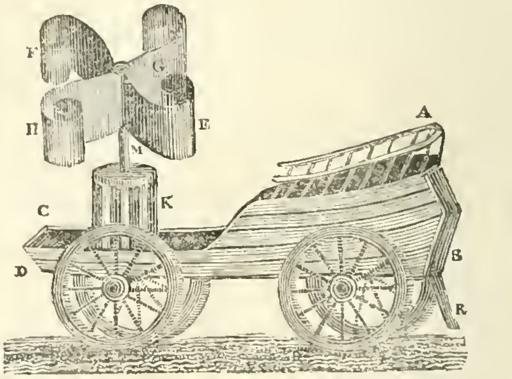
Description of different Carriages that move without Horses.—In the annexed figure is represented a carriage invented by Mr. Richard, a physician in Rochelle, which moves without horses, merely by the exertion of the passengers. The machinery by which this is effected, is placed in a box behind the carriage, and is shewn in the 2d figure, where A A is a small axis fixed in the box, and B a pulley, over which a rope passes, whose two extremities are tied to the ends of the levers or treddles C, D; the other ends of the levers are fixed by joints to the cross beam. The cranks F F are fixed to the axle K L, and move upon it as a centre. Each of them has a detent tooth at F, which catches in the teeth of the wheels H, H, so that they can move from F to H without moving the wheel, but the detent tooth catches in the teeth of the wheels when the cranks are brought backward, and therefore bring the wheel along with them. When the foot of the passenger, therefore, is placed upon the treddle D, it brings down the crank F and along with it the wheel H, so that the large wheels fixed on the same axis perform part of a revolution; but when D is depressed, the rope D A descends, the extremity C of the other treddle rises, and the crank F rising along with it, takes into the teeth of the wheel H, so that when the elevated treddle C is depressed, the wheels H, H, and consequently the wheels I, I, perform another part of a revolution. In this way, by continuing to work at the treddles, the machine advances with a regular pace.

A carriage of this kind, where the mechanism is much more simple and beautiful than that which we have described, has been lately invented and constructed by Mr. Nasmyth, of Edinburgh, a gentleman whose mechanical genius is scarcely inferior to his talents as a painter. The pulley B and axle A A, are rendered unnecessary; leather straps are substituted in place of the cranks F, F, and the whole mechanism is contained in two small cylindrical boxes, about six inches in diameter, and one and a half broad.



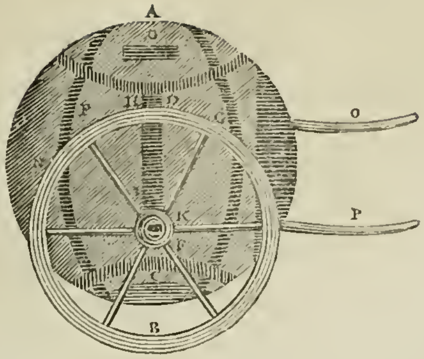
A carriage driven by the action of the wind is exhibited in the annexed figure. It is fixed on four wheels, and moved by the impulse of the wind upon the sails C, D, being guided by the rudder E. Carriages of this kind will answer very well in a level country where the roads are good and the wind fair; and are said to be used in China. In Holland they sometimes use similar vehicles for travelling upon the ice; but they have a sledge instead of wheels, so that if the ice should happen to break, there will be no danger of sinking. Stephinus, a Dutchman, is said to have constructed one of these carriages with wheels, which travelled at the rate of 21 miles an hour with a very strong wind.

Dr. Phebus, of New York, has caused a wheel to be constructed which is put in motion by the wind. The plan of it is very simple. It has eight horizontal spokes attached to a perpendicular axle. Every one of the spokes is furnished with a sail which extends or contracts at pleasure, something like the sails of a vessel. Every sail is hooked up, from the right to the left, to the first loop of that which follows; and they are sufficiently large to receive the full impulse given by the wind. This machine, which is more easy to conceive than to describe, is very ingenious, and may be employed in a great number of manufactures.



The carriage represented in the annexed figure, is made so as to sail against the wind by means of the spiral sails E, F, G, H, one of which, F, is expanded by the wind. The impulse of the wind upon the sails gives a rotatory motion to the axle M, furnished with a cog-wheel K, whose trundles act upon teeth placed on the inside of the two fore wheels.

A carriage which cannot be overturned, is represented in the next figure, where A B is the body of the carriage, consisting of a hollow globe, made of leather or wood, at the bottom of which is placed an immoveable weight. Two horizontal circles of iron, D, E, connected with bars H, I, and two vertical circles F, G, surround the globe; and the wheels are

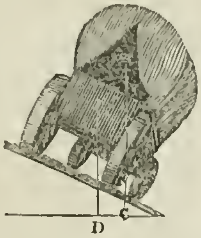


fastened by a handle K to the perpendicular bars H, I. O, P, are handles or shafts by which to move the machine along. N is one wheel, and on the opposite side is another. O is a window. The door may be next to O P. Then, since the body of the carriage moves freely in every direction within the iron circles, the centre of gravity will always be near C, and the carriage will preserve an upright position even if the wheels and frame were overturned.

Stage Coaches and Waggons.—The danger of a *stage coach* overturning, arises either from two wheels on one side being driven into a hole, a ditch, or over a high bank, or running quickly to the side of a road very much rounded from its crown; or from turning a sharp corner with great velocity.

The *breaking down* of any coach is a disastrous and fatal accident, which will happen in future, as it has happened heretofore; and can only be prevented by the use of two pairs of idle wheels placed within the wheels in use, which is much the same as if we were travelling in two separate carriages.

A coach may be overturned by the centre of gravity being placed too high. Holes, ditches, banks, rounded roads, corners, and unequally loading to displace the centre of gravity, are all to be avoided by care, skill, and prudence; and in general by having the wheels perpendicular to the road, *i. e.* to the horizon, for the broader the base, and the nearer the line of direction is to the centre, the more firmly does the coach roll along; on the contrary, the narrower the base, *i. e.* the wheels, such as the conical, and the nearer the line of direction is to its side, the more easily may the coach be overthrown.



Suppose an overloaded waggon slopes on an uneven road, as shewn in the annexed figure, till the centre of gravity is at the point A; your eye will tell you that a vehicle thus situated, must overset; and the reason is, that the centre of gravity A, is not supported; for if you draw a perpendicular line from it to the ground at C, it does not fall under the waggon within the wheels, and is therefore not supported by them. If, however, we remove the centre of gravity to B, by taking off the upper part of the load, the waggon will not overturn, because the line of direction B D falls within the wheels at D.

The wheels of carriages turn round, on account of the friction they sustain in contact with the roads; and large wheels are more advantageous than small ones. In four-wheeled carriages, the fore wheels are made smaller than the hind ones, for the conveniency of turning; otherwise they would be better of the same size. Broad wheels are better for heavy carriages—such as waggons—because they press and harden, instead of cutting up the roads, as small wheels do.

Much attention has of late been paid to the safety of passengers, by the construction of coaches in which the centre of gravity is brought very low, and the risk thereby greatly lessened. The legislature should pass an act to compel waggon-masters, van-proprietors, and coach-makers, to turn out such machines only as have their centres of gravity placed within the line of direction, when loaded at their utmost draught. It may be indifferent to draught, whether a ton be placed on the roof of a coach, or at its floor 2 feet from the ground; but it is material to danger and safety, that a ton weight be within 2, rather than 7 feet of the ground.

CARTES, Rennes des, a celebrated French mathematician. Des Cartes explains mechanically how the world was formed, and how the present phenomena of nature came to arise. He supposes that God created matter of an indefinite extension, which he separated into small square portions or masses, full of angles: that he impressed two motions on this matter; the one, by which each part revolved about its own centre; and another, by which an assemblage, or system of them, turned round a common centre. From whence arose as many different vortices, or eddies, as there were different masses of matter, thus moving about common centres.

The consequence of these motions in each vortex, according to Des Cartes, is as follows:—The parts of matter could not thus move and revolve amongst one another, without having their angles gradually broken; and this continual friction of parts and angles must produce three elements; the first of these, an infinitely fine dust, formed of the angles broken off; the second, the spheres remaining after all the angular parts are thus removed; and those particles not yet rendered smooth and spherical, but still retaining some of their angles and hamous parts, from the third element.

Now the first or subtilest element, according to the laws of motion, must occupy the centre of each system, or vortex, by reason of the smallness of its parts: and this is the matter which constitutes the sun, and the fixed stars above, and the fire below. The second element, made up of spheres, forms the atmosphere, and all the matter between the earth and the fixed stars, in such sort, that the largest spheres are always next the circumference of the vortex, and the smallest next the centre. The third element, formed of the irregular particles, is the matter that composes the earth, and all terrestrial bodies, together with comets, spots in the sun, &c.

He accounts for the gravity of terrestrial bodies from the centrifugal force of the ether revolving round the earth; and upon the same general principles he pretends to explain the phenomena of the magnet, and to account for all the other operations in nature.

Des Cartes infers the existence of God from the principle, "*Cogito, ergo sum;*" "I think, therefore I am!" and thinks his inference just, because it satisfies his reason: he proceeds on a supposition, that what satisfies his reason is true; and takes it for granted, that his reason is not a fallacious but a true faculty: hence his argument proceeds on a supposition, that the point to be proved is true. He therefore attempts to prove the truth of our faculties by an argument which evidently and necessarily supposes their truth; and consequently his metaphysics is built on sophisms. As this philosopher doubted where he ought to have been confident, so he is often confident where he ought to doubt. He admits not his own existence till he thinks he has proved it; yet his system is replete with hypotheses, taken for granted without proof, almost without examination. He sets out with the profession of universal scepticism, while many of his theories are founded on the most unphilosophical credulity. Des Cartes erred materially when he concluded, that the most perfect kind of science was to be arrived at by inferring effects from their causes; for, consistently with this conclusion, he endeavoured, from his knowledge of the Deity, (which must necessarily be imperfect,) to deduce an explication of all his work, and thus produced a system almost in every respect repugnant to truth and experiment. Des Cartes was so far from applying geometry and observations to natural philosophy, that his whole system is one continued blunder, on account of his negligence in that point. His theory of vortices, upon which his system is founded, is absolutely false; for Newton has shewn, that the periodical times of all bodies that swim in vortices, must be directly as *the squares of their distances* from the centre of them; but it is evident, from observations, that the planets, in moving round the sun, observe a law quite different from this; for the squares of their periodical times are always as *the cubes of their distances;* and therefore, since they do not observe that law, which of necessity they must if they swim in a vortex, it is a demonstration that there are no vortices in which the planets are carried round the sun; and therefore Des Cartes' hypothesis is absurd, irrational, and not capable of mathematical proof.

The Cartesian system has been often altered and mended; many ingenious men, for full a century, employing their talents in reforming one part and new-modelling another. But it is now acknowledged on all hands, that the foundation was faulty, and the superstructure erroneous; so that the fabric, though allowed to be a work of genius, is abandoned to neglect and ruin, and is pointed at as a memorial of philosophical presumption. Yet this system, or one much more absurd, has been broached of late, by a person who denominates his vagaries, "the philosophy of Atomic motion." Des Cartes died in 1650.

CARTWRIGHT, a person who makes carts, ploughs, harrows, wheelbarrows, and in short all sorts of country and farming carpentry,—for the word *wright* signifies in the North, *a joiner*. But cartwrights are confounded with *wheelwrights*, though the latter only were recognized in old times as the legitimate makers of carriages, of what name soever these might be called.

CASKS, *The Manufacture of*, is now much facilitated by machinery, which was invented by Messrs. Plakete and Brown, in 1811, and is thus perspicuously described in Dr. Gregory's "Mechanics."

"First. The machinery for cutting the stave consists of a stout bench, having a board or platform annexed to it, capable of being moved endways, to which another board is connected, so arranged as to be moved across it steadily by racks and pinions, or screws. This last board has a hollow part made in it, in which the staveboard may be laid, so that one edge of it may project clear beyond the edge of the first mentioned board: a circular saw is placed either above or below the bench, having its axis at right angles to the line of motion of the first mentioned board, and opposed to the direction of the course of the projecting part of the staveboard: this circular saw is made flat, when the straight-edged staves are to be cut; and is dished, or of a spherical shape, when staves with curved edges are wanted.

"The board first mentioned is moved either in a right line, or is made to assume a curved course by being confined in its motion by curved grooves, or by curved rods moving against pins; and by the proper management of these sliding boards, the staveboard is cut by the circular saw, of the shape desired.

"The machinery next used consists of a large lathe, in which the cask is turned in a vertical position when it is of a large size, (after it is formed in the usual manner from the staves prepared as above described,) being either fixed in a great chuck placed beneath it, or in a cylindrical cage, which surrounds it, fixed upon a strong upright arbor, and revolving between collars, where it serves the office of a mandril. In this lathe the chime and groove for receiving the head are turned in the cask by the application of a proper tool. When the cask is small, the cage is made to turn in a horizontal position, instead of revolving vertically.

"The third operation is to form the head, which is pinioned together as usual, after having the pinholes made by piercers, projecting from the mandril of a lathe; the distances and depth of which holes are correctly regulated by gauges; it is then turned on a flat revolving table, from which points project to hold it fast, and against which it is held by another revolving piece, that is screwed towards the first, where it is brought to the proper size of the cask by fit tools.

"The fourth operation is to turn the whole cask at the outside; for which purpose, it is placed in a large lathe between two chucks, made to fit into the chines, and attached to the head by points; and then the surface of the cask is turned smooth by a spokeshave, or other fit instrument, held against it by a rest properly placed for the purpose.

"The patentees bend the wooden hoops for their casks in a more expeditious manner, by fastening one end of them to the circumference of a wheel, and pressing them against the wheel as it is turned round: they also describe a method of forming the projecting part in the bung staves of the small casks, called bottles, by flat or concave circular saws, which cut the face of the stave on each side close up to the projection; and lastly, in giving motion to this machinery, the inventors use any of the usual first movers, and millwork, as may be necessary."

CASSINI, JOHN DOMINIC, an eminent astronomer, born at a town in Piedmont, in 1625. In 1650 he was invited to the senate of Bologna to be their public mathematical professor, while he was yet but twenty-five years of age. He resolved an astronomical problem, which Kepler and Bullialdus had given up as insolvable, *viz.* to determine geometrically the apogee and eccentricity of a planet, from its true and mean place. In 1666 he printed at Rome a collection of astronomical pieces, and among others, a "Theory of Jupiter's Satellites." Cassini died in 1712, in the 87th year of his age.

CASSINI, *John James*, the son and successor of the above, born at Paris in 1677, and educated at the Mazarine College, under Varignon, Professor of Mathematics. At the age of seventeen he was admitted a member of the Academy of Sciences; and in 1696 he visited England, where he was chosen a Fellow of the Royal Society. He succeeded his father in 1712, and enriched the stock of science with many valuable discoveries. He died in consequence of a fall, in 1756.

CASSIOPEIA, one of the Northern Constellations, represented as the Wife of Cepheus, and Mother of Andromeda, but is called *El Seder*, the Cedar tree, by Ulug Beig.—The boundaries and contents are: north by Tarandus, east by Camelopardalis and Perseus, south by Andromeda, and west by Cepheus. This constellation, situated between 45° and 75° north declination, passes vertically over the British isles, and a large portion of Europe. It lies between 47° and 55° right ascension. It contains 55 stars, *viz.* five of the 3d magnitude, five of the 4th, &c. The head and body of this lady are placed in the Milky Way, her right foot resting on the Arctic Circle. Relatively to the two Bears, Cassiopeia is placed opposite to the space between them, and she is very easily distinguished by five stars of the 3d magnitude. In the year 1752, Tycho Brahe discovered in this constellation, a new star which shone with more light than Venus, till 1574, when it disappeared entirely. *Schedir*, *a*, having 7° 35′ 7″, or 0^h 29′ 40″ right ascension, and 55° 32′ 58″ declination north, culminates or comes to the meridian at London, for the first day of every month during the year, as shewn in the following table: Meridian Altitude 85° 58′ 2″ north.

MONTH.	CULM.	MONTH.	CULM.	MONTH.	CULM.
	ho. mi.		ho. mi.		ho. mi.
Jan.	5 43 A.	May	9 51 M.	Sept.	1 41 M.
Feb.	3 31 A.	June	7 41 M.	Oct.	11 54 A.
March	1 46 A.	July	5 41 M.	Nov.	10 1 A.
April	11 41 M.	Aug.	3 41 M.	Dec.	7 56 A.

CASTING and MOULDING. The art of taking impressions from pieces of sculpture, medals, &c. is of importance in the fine arts. To procure a cast from any figure, bust, medal, &c. it is necessary to obtain a mould, by pressing upon the thing to be copied some substance capable of being forced into all the cavities or hollows of the sculpture. When this mould is dry and hard, some substance which will fill all the cavities of the mould is poured into it: the form of the original from which the mould was taken, is now accurately represented. Moulding in any particular manner depends upon the form of the subject. When there are no projecting parts but such as form rectilineal angles with the principal surface of the body, nothing more is necessary than to cover it over with the substance of which the mould is to be formed, and to take it off clean, and without bending. It may be laid horizontally, and will bear to be oiled without injury.

The substances used for moulding are various, according to the nature and the situation of the sculpture, as wax, metal, plaster of Paris, &c. This last is prepared in a fine powder mixed with water, and poured over the mould to a convenient thickness, after oiling it, to prevent the plaster from sticking. A composition of bees' wax, resin, and pitch, makes a very desirable mould, if many casts are to be taken. If the situation of the sculpture be perpendicular, clay, or some similar substance, must be used. The best kind of clay is that with which sculptors make their models; it is worked to a due consistence, and having spread it out to a size sufficient to cover all the surface, it is sprinkled over with whiting, to prevent it from adhering to the original. Bees' wax and dough, or the crumb of new bread, may also be used for moulding some small subjects, as impressions of seals and bijoux. When there are undercuttings in the bas-relief, they must be first filled up before it can be moulded, otherwise the mould could not be got off. When the casts are taken afterwards, these places must be worked out with a proper tool. When the model, or original subject, is of a round form, or projects so much that it cannot be moulded in this manner, the mould must be divided into several parts; and it is frequently necessary to cast several parts separately, and afterwards to join them together.

In this case, the plaster must be tempered with water to such a consistence, that it may be worked like soft paste, and laid on with some convenient instrument, compressing it till it adapt itself to all parts of the surface. When the model is thus covered to a convenient thickness, the whole is left at rest till the plaster become firm, so as to bear dividing without falling to pieces by any slight violence; it must then be divided into pieces to be taken from the model. This is done by cutting it with a thin-bladed knife; being now divided, it must be cautiously taken off, and kept till dry; but, before the separation of the parts is made, they are notched across the joints, at proper distances, that they may with certainty be put together again. The art of properly dividing the moulds, to make them separate from the model, requires dexterity and skill. Where the subject is of a round or spheroidal form, it is best to divide the mould into three parts, which will then easily come off from the model; and the same will hold good of a cylinder, or any regular curve figure.

The mould being thus formed, and dry, and the parts put together, it must be first oiled, and placed in such a position that the hollow may lie upwards. It is then filled with plaster mixed with water; and when the cast is perfectly set and dry, it is taken out of the mould, and repaired where necessary. This finishes the operation. In larger masses, where there would otherwise be a great thickness of the plaster, a core may be put within the mould, as was observed in regard to the casting of statues, to produce a hollow in the cast. This saves expense of plaster, and renders the cast lighter.

In the same manner, figures, busts, &c. may be cast of lead, or any other metal, in the moulds of plaster or clay; the moulds must be perfectly dry, for should there be any moisture, the sudden heat of the metal will convert it into vapour, and produce by its expansion, an explosion, that would blow the melted metal about to the great danger of the artist.

To take a Cast in Metal from any small Animal, Insect, or Vegetable.—Prepare a box, sufficiently large to hold the animal, in which it must be suspended by a string: the legs, wings, &c. of the animal, or the tendrils, leaves, &c. of the vegetable, must be separated and adjusted in their right position by a pair of pincers. A due quantity of plaster of Paris mixed with talc, must be tempered to a proper consistence with water, and the sides of the box oiled. Also a straight piece of stick must be put to the principal part of the body, and pieces of wire to the extremities of the other parts, that they may form, when drawn out after the matter of the mould is set and firm, proper channels for pouring in the metal, and vents for the air, which otherwise, by the rarefaction it would undergo from the heat of the metals, would blow it out, or burst the mould. In a short time the plaster will set, and become hard; the stick and wires may now be drawn out, and the frame in which the mould was cast taken away; and the mould must then be put, first, into a moderate heat, and, afterwards, when it is as dry as it can be rendered by that degree, removed into a greater, which may be gradually increased, till the whole be red hot. The animal or vegetable enclosed in the mould will then be burnt to a coal; and may be totally calcined to ashes, by blowing for some time into the charcoal and passages made for pouring in the metal, and giving vent to the air. This operation, at the same time that it destroys the remainder of the animal or vegetable matter, will blow out the ashes. The mould is then allowed to cool gently; the destruction of the substance that had been included in it, has now produced a corresponding hollow; but it may nevertheless be proper to shake the mould, and blow with bellows into each of the air vents, to free it wholly from any remaining ashes; where there may be an opportunity of filling the hollow with quicksilver, it will be found an effectual method of cleaning the cavity, as all dust and ashes must rise to the surface of the quicksilver, and be poured out with it.

The mould being thus prepared, must be heated very hot, when used, if the cast is to be made of copper or brass, but a less degree will serve for lead or tins. The metal being poured into the mould, it must be gently struck, and then suffered to rest till it be cold; it is then carefully taken from the cast, but without force; such parts of the matter as appear to adhere more strongly, are to be softened, by soaking in water till they be entirely loosened, that none of the more delicate parts of the cast may be broken off or bent.

When talc cannot be obtained, plaster alone may be used; it is apt however to be calcined, by the heat used in turning the animal or vegetable from whence the cast is taken, and to become of too incoherent and fusible a texture. Stourbridge clay, washed perfectly fine, and mixed with an equal part of fine sand, may be employed. Pounded pumice-stone, and plaster of Paris, in equal quantities, mixed with washed clay in the same proportion, make excellent moulds.

To take a Cast in Plaster from a Person's Face.—The person whose likeness is required in plaster, lays down on his back, the hair is tied back, so that none of it may cover the face. Into each nostril a conical piece of stiff paper open at both ends is conveyed, to allow of breathing. The face is then lightly oiled over with salad-oil, to prevent the plaster from sticking to the skin. Fresh burnt plaster is mixed with water to a proper consistence, and poured in spoonfuls all over the face, (taking care the eyes are shut,) till it is entirely covered to the thickness of a quarter of an inch. This substance will grow sensibly hot, but this the patient must not fear; for in a few minutes the plaster will be hard. This being taken off, will form a mould, in which a head of clay may be moulded, and therein the eyes may be opened, and such other additions and corrections may be made as are necessary. Then, this second face being anointed in oil, a second mould of plaster is made upon it, consisting of two parts joined lengthwise along the ridge of the nose; and in this a cast in plaster is taken, as an exact likeness of the original.

To take Casts from Medals.—To take copies of medals, a mould must first be made, of plaster of Paris, or of melted sulphur. After having oiled the surface of the medal with a little cotton, or a camel's hair pencil dipped in oil of olives, a hoop of paper must be put round the medal, standing up above the surface, of the thickness you wish the mould to be. Take now some plaster of Paris, mix it with water to the consistence of cream, and with a brush rub it over the surface of the medal, to prevent airholes from appearing; then immediately afterwards make it to a sufficient thickness, by pouring on more plaster. Let it stand half an hour, when it will have grown so hard, that you may safely take it off; then pare it smooth on the back, and round the edges neatly. In cold or damp weather it should be dried before a brisk fire. When the mould is large, if you cover its face with fine plaster, a coarser sort will do for the back: but no more plaster should be mixed up at one time than can be used, as it will soon get hard, and cannot be softened without being burned over again. Sulphur must not be poured upon silver medals, as this will tarnish them.

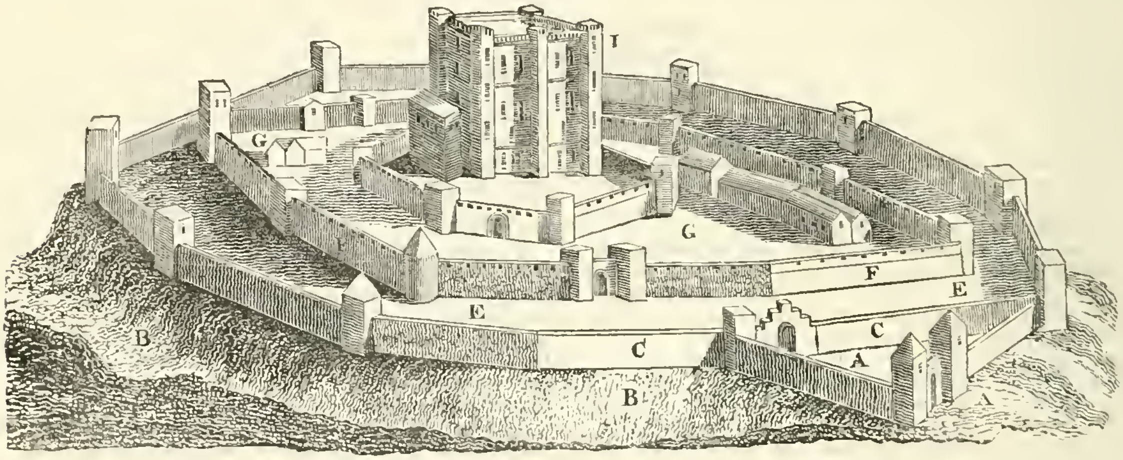
To prepare your mould for casting sulphur, put plaster of Paris into it, take half a pint of boiled linseed oil, and one ounce of oil of turpentine, and mix them together in a bottle; dip the surface of the mould into this mixture; take the mould out again, and when it has sucked in the oil, dip it again. Repeat this till the oil begins to stagnate upon it; then take a little cotton wool, hard rolled up, to prevent the oil from sticking to it, and wipe it carefully off. Lay it in a dry place for a day or two, (if longer the better,) and the mould will acquire a very hard surface from the effect of the oil. To cast plaster of Paris in this mould, proceed with it in the same manner as above directed for obtaining the mould itself, first oiling the mould with olive oil. When casts are wanted of sulphur, the material must be melted in an iron ladle.

To take Casts with Isinglass.—Dissolve isinglass in water over the fire. With a hair brush lay the wetted isinglass over the medal. Cover it properly, and let it dry. When hard, raise the isinglass with the point of a knife, and it will fly off like horn, leaving a sharp impression of the medal. You may make the isinglass of any colour, by mixing that colour with it when in a state of solution; or you may breathe on the concave side, and lay gold leaf on it, which, by shining through, will make it appear like a gold medal. A little carmine mixed with the isinglass will give it the appearance of a copper medal, observing to lay the gold on the concave side.

To cast Small Works in Sand.—The sand is usually a soft yellowish clammy substance; but as we see it in an iron foundery, it is black, from the charcoal which the workmen strew over it. This sand, after being placed over a trough to receive it, is worked on a board, with a roller and a knife. The workmen then take a board, putting a ledge round, and fill it with sand, a little moistened, to make it cohere. Then the wood or metal models of what is intended to be cast, are applied to the mould, and pressed into the sand, to leave the impression. Along the middle of the mould, half of a small brass cylinder is laid; the metal runs through this chasm into the models; from this are placed several others, to each model placed in the frame. After the frame is finished, the workmen then take out the patterns, by loosening them all round, that the sand may not give way. They then work the other half of the mould with the same patterns, in another frame. In this last frame are pins, which, entering into correspondent holes in the other, make the two cavities of the pattern fall exactly on each other. The frame thus moulded, is carried to the melter. He extends the chief canal of the counterpart, adds the cross canals to the several models in both, and strewing mill-dust over them, dries them in an oven. Both parts of the mould being dry, are joined by the pins, and screwed up like a press. While the moulds are preparing, the metal is fusing in a crucible of a size proportionate to the quantity of metal intended to be cast.

To cast Cannon.—The casting cannons, mortars, and other pieces of ordnance, is like that of statues and bells, especially as it regards the mould, wax, shell, furnaces, &c. The metal is different, however, having a mixture of tin, which is not in that of statues; and only half the quantity of tin that is in bells, at the rate of ten pounds weight of tin to a hundred of copper. Cannons are always thickest at the breach, where the greatest effort of the gunpowder is made, and diminishing thence to the muzzle; so that if the mouth be two inches thick of metal, the breech is six. Its length is measured in calibers, or diameters of the muzzle. Six inches at the muzzle require twenty calibers, or ten feet in length; there is about one-sixth of an inch allowed for the deviation of the ball, and in this manner are all our guns estimated.

CASTLE, a Fortress, or building rendered defensible either by nature or art. In the following engraving, A is the *barbican;* B the *ditch,* or moat; C the *wall* of the outer ballium; or the outer *ballium;* E the *artificial* mount; F the wall of the inner *ballium;* G the *keep,* or dungeon. All the towers, magazines, &c. speak for themselves. Between the outer ballium and the barbican, and directly over the moat or ditch, the drawbridge is constructed, opening or rising to the ballium gate, and leaving the way impassable to those who may try to force and enter the barbican.



CASTOR and POLLUX, the allegorical figures in the sign Gemini, which give name to the two principal stars in that constellation.

CAT, in sea affairs, a ship of 600 tons or thereabouts, carrying from 20 to 30 *keels* (or barges) of coals. Cat is also a tackle, or combination of pulleys, to suspend the anchor at the *cat's-head.*

CATACOMB, a Grotto, or subterraneous place for the burial of the dead, as the sepulchre of the martyrs in the Appian Way, about three miles from Rome; the catacombs of Naples, Syracuse, Catanea, Malta, Paris; but above all, those in Egypt are the most celebrated.

CATALOGUE, a list or enumeration of books, or of the stars, or of the Popes, as the Jesuit's *Propilæum.*

CATAPULTA, in Antiquity, a military engine for throwing stones or darts upon an enemy; but modern warfare dispenses with those awkward machines, and so shall we.

CATARRH, in Medicine, a distillation or defluxion from the head upon the mouth and *aspera asteria,* and through them upon the lungs

CATENARY, Catenaria, in the higher Geometry, a mechanical curve, which a chain or rope forms itself into by its own weight, when hung freely between two points of suspension, whether those points be in the same horizontal plane or not. *See* Chain Bridge.

CATGUT, fiddle strings, made of the dried and twisted guts of sheep, lambs, dogs, and cats. The Lyonois and Italians are the great manufacturers of catgut for our musicians, watchmakers, cutlers, turners, and other artificers.

CAT-HEADS, two strong short beams of timber, projecting almost horizontally over the ship's bows on each side of the bowsprit. That part of the cat-head which rests upon the forecastle is securely bolted to the beams; the other projecting part carries in its extremity two or three small wheels, or sheaves of brass or strong wood, about which a rope called the *cat-dole* passes, and communicates with the cat-block, which also contains three sheaves. The cat-head also serves to suspend the anchor clear of the bow, when it is necessary to let it go: it is supported by a sort of knee, which is generally ornamented with sculpture.

CATOPTRICS, the science of reflex vision, which is treated of under the article Mirror.

CATSALT, formed out of the bittern, or leach brine, that runs from the salt when taken from the pans at the salt works, is very beautifully granulated, sharp and pungent, and much more pleasant at the table than the fine but white powdered salt in common use. Fashion, not taste, must have consigned the large beautiful crystals of catsalt to the makers of hard soap and fish curers.

CAT'S-EYE, or **SUN STONE**, a gem whose colours vary like the *opal*, very hard, semitransparent; and which, from the several points it may have naturally, or into which lapidaries can fashion it, reflects the light with a kind of yellowish radiation, something similar to the eyes of a cat, whence the name of this Siberian onyx.

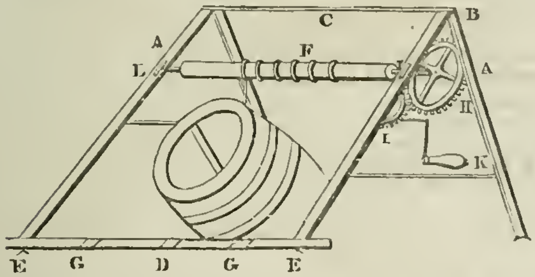
CAUSTIC, or **CATACAUSTIC CURVES**, in the higher Geometry and Optics, are the species of curves formed by reflection, or by joining the points of concurrence of several reflected rays. The caustic of the circle is a cycloid, or epicycloid, formed by the revolution of a circle upon a circle. The catacaustic of the common cyloid, when the rays are parallel to its axis, is also a common cycloid, described by the revolution of a circle upon the same base. That of a logarithmic spiral is also the same curve. If the inside of a smooth bason, containing in it any white liquor, as milk, be placed in the sun's rays, or in a strong candlelight, it will exhibit a very perfect catacaustic curve.

CAWKING or **CAULKING** a ship, is driving a quantity of oakum, or untwisted rope, into the seams of the bottoms and decks of ships, in order to prevent the entrance of water; and *caulking irons* are chisels for that purpose, being some broad, some round, and some grooved.

CELA SCULPTORIS, or **PRAXITELES**, *the Engraver's Tools,* is a small modern constellation, bounded on the north by Lepus, east by Columbia, south by Equuleus Pictorius; and west by Horologium and Eridanus. There are sixteen stars assigned to this asterism, in the Britannic Catalogue.

CELESTIAL, relating to the heavens; hence we say *Celestial Globe*, *Celestial Atlas*, &c.

CELLAR CRANE, a machine represented in the following figure, and is very useful to wine-merchants, brewers, &c. in drawing up and letting down casks full of wine, beer, &c. It saves the trouble and inconvenience of horses, and in many places can be used where horses could not. A, A are two wooden props, about 6 feet in height, and jointed together like a ruler at B. They are connected to each other by an iron round bar C, and wooden bar at the bottom, D. The iron prongs E E fasten the uprights steadily to the edge of the cellar; F is the axis round which two ropes are coiled, the ends of which are fastened to the two clamps G, G. On the axis F is fixed the iron wheel H of 3 feet in diameter: in the teeth of this works the pinion I, of about 6 or 7 inches in diameter, and is turned by the handle at K. It is evident, by the figure, that when the two ropes are slipt over the ends upon the barrel, either at the top or bottom of the cellar, by turning of the wineb K towards or from the operator, the barrel can be safely and expeditiously taken out or lowered down. When the crane is done with, it shuts up, by unscrewing the nut B, taking the wheel and axis away out of the loops at L, and folding the sides at A together, like a jointed rule; it may then be taken away in the cart or dray, or taken in the men's hands.



CEMENT, in general, is any glutinous substance capable of uniting and keeping things together in close cohesion. Cements are of various compositions, according to the substances to which they are applied, and their exposure to heat and moisture.

Common Glue.—Common glue is formed by extracting the gelatinous part of cuttings or scraps of coarse leather, or the hides of beasts: it is never manufactured but in a large way.

Isinglass Glue.—Isinglass glue is made by dissolving beaten isinglass in water by boiling; having strained it through a coarse linen cloth, it evaporates again to such a consistence, that, being cold, the glue will be hard and dry. This cement is improved by dissolving the isinglass in proof spirit by heat, or by adding to it, when dissolved in water, an equal quantity of spirits of wine. It is still further improved, by adding to the isinglass, previous to its solution in spirits, one-third of its weight of gum ammoniac. Expose the mixture to a boiling heat until the isinglass and gum are dissolved, and until a drop of the composition becomes instantly stiff as it cools. It will in future melt with a degree of heat little exceeding that of the human body, and, in consequence of becoming stiff in cooling, forms a valuable cement for fixing on the antennæ, &c. of insects in the cabinet of natural history. The easy melting of this cement is no objection to its use, for it owes this property only to the presence of the spirit, which evaporates soon after it has been applied. When used to join broken glass or china, the pieces should be previously warmed, and immersion in hot water will give them a sufficient degree of heat. Wipe off the water before applying the cement, which may be laid on with a pencil; then press the pieces together, binding them with a string or a bit of soft wire, if necessary. For nice purposes, this isinglass glue is preferable to common glue, being stronger, and less liable to soften by heat or moisture.

Parchment Glue is made of one pound of shreds of parchment or vellum, boiled in six quarts of water, till the quantity be reduced to one quart; the fluid is strained off from the dregs, and then boiled again till it be of the consistence of glue. Glovers' cuttings of leather dressed with alum, instead of being tanned, makes a colourless glue.

To make Signboard Glue.—Melt common glue with water to a proper consistence; add one-eighth of boiled linseed oil, dropping it gently into the glue, which is to be kept stirring all the time. A strong glue is made by adding some powdered chalk to common glue, and another that will resist water by adding half a pound of common glue to two quarts of skimmed milk.

To prepare Lip Glue for Cementing Paper, &c.—Take of isinglass and parchment glue, each one ounce; of sugarcandy, and gum tragacanth, each two drachms; add to them an ounce of water, boil the whole, till the mixture appears, when cold, of the consistence of glue. Then form it into small rolls for use. This glue wetted with the tongue, and rubbed on the edges of the paper, silk, &c. to be cemented, will, on their being laid together, and suffered to dry, unite them as firmly as any other part of the surface.

Lapland Glue.—Laplanders' bows are composed of two pieces of wood glued together; one of them of birch, which is flexible, and the other of fir of the marshes, which is stiff, in order that the bow when bent may not break, and that when unbent it may not bend. When these two pieces of wood are bent, all the points of contact endeavour to disunite themselves, and to prevent that, the Laplanders employ the following cement:—They take the skins of large perches, and having dried them, moisten them in cold water until they are so soft that they may be freed from the scales, which are thrown away; probably eel skins would answer the same purpose. They then put four or five of these skins into a reindeer's bladder, or they wrap them up in a soft bark of the birch tree, in such a manner that water cannot touch them, and place them thus covered into a pot of boiling water, with a stone above them to keep them at the bottom. When they have boiled about an hour, they take them from the bladder or bark, and they are then found to be soft and viscous. In this state they employ them for glueing together the two pieces of wood which compose their bows, and which they strongly compress and tie up till the glue is well dried. These pieces never after separate.

Cheese Glue.—Take skimmed milk cheese, freed from the rind, cut it into slices, boil it in water, stirring it with a spoon until it be reduced to a strong glue, which does not incorporate with water; then throw away the hot water; pour cold water over the glue, and knead it afterwards in warm water, subjecting it to the same process several times. Put the warm glue on a grinding stone, and knead it with quicklime until you have a good glue. To use this glue you must warm it; employed cold, it is not so strong, but it may be used in that manner. This glue is insoluble in water as soon as it is dry, and it becomes so in forty-eight hours after it has been applied.

It may be used for glueing wood, cementing marble, and broken earthenware. Baits for catching fish may also be made of it. Fish are very fond of it, and it resists water.

Jewellers' Cement.—In setting precious stones, pieces are sometimes broken off by accident, but these may be joined so correctly, that an inexperienced eye would not discover the stone to have been broken. Jewellers employ for this purpose a small piece of gum mastich applied between the fragments, which are previously heated sufficiently to enable them to melt the interposed gum. They are then pressed together, to force out the redundant gum.

Turkey Cement for joining Metals, Glass, &c.—Dissolve six bits of mastich, as large as peas, in as much spirits of wine as will suffice to liquefy; in another vessel dissolve as much isinglass (which has been previously soaked in water till it has swollen and is soft) in brandy or rum, as will make two ounces by measure of strong glue, and add two small bits of gum galbanum, or ammoniacum, which must be rubbed till they are dissolved; then mix the whole with a sufficient heat; keep it in a phial stopped, and when used set it in hot water.

Broken China Cement.—Take quicklime and white of eggs, or old thick varnish; grind and temper them well, and it will be ready for use. Drying oil and white lead are used for cementing china and earthenware; but this cement requires a long time to dry. Where the vessels are not to endure heat or moisture, isinglass glue, with a little tripoli or chalk, is better; the juice of garlic also forms a strong cement, and the joining cannot easily be perceived.

Chemical-Glasses' Cement.—In the whites of eggs mix equal quantities of wheat flour, fine powdered Venice glass, pulverized chalf, with half the quantity of fine brick dust, and a little scraped lint. This mixture is spread upon a linen cloth, and applied to the crack of the glasses; it should be dried before they are put to the fire.

Turner's Cement.—Melt together resin one pound, pitch four ounces; and, while boiling hot, add brick dust, until, by dropping a little upon a stone, you perceive it hard enough; then pour it into water, and immediately make it up in rolls, and it is fit for use.

Another, finer. Take resin one ounce, pitch two ounces; add red ochre, finely powdered, until you perceive it strong enough. Sometimes a small quantity of tallow is used, according to the heat of the weather, more being necessary in winter than summer. Either of these cements is of excellent use for turners. By applying it to the side of a chuck, and making it warm before the fire, you may fasten any thin piece of wood, which will hold fast while you turn it; when you want it off again, strike it on the top with your tool, and it will drop off immediately.

Electrical Cement.—Melt in a pot, over a slow fire, one pound of resin; add as much plaster of Paris, in fine powder, as will make it hard enough, which you may know by trial; then add a spoonful of linseed oil, stirring it all the while, and try if it be hard and tough enough for your purpose; if it is not sufficiently hard, add more plaster of Paris; and if not tough enough, a little more linseed oil. This is for fixing the necks of globes or cylinders, or any thing that requires to be strongly cemented, for it is not easily melted when cold.

Another, softer. Take resin one pound, bees' wax one ounce; add as much red ochre as will make it sufficiently stiff; pour it into water, and make it into rolls for use. This cement is for cementing hoops on glasses, or any other mounting of electrical apparatus.

Glass Grinders' Cement.—Boil pitch, adding thereto fine sifted wood ashes, until you have it of a proper temper, stirring it all the while; a little tallow may be added, as you find necessary.

Another, for small work. To four ounces of resin add one-fourth of an ounce of bees' wax, melt them together, adding four ounces of whitening made previously red hot. The whitening should be put while hot, that it may not have time to imbibe moisture from the atmosphere. Shell lac is a strong cement for metals, glass, or precious stones, while cutting, twining, or grinding them. The metal, &c. should be warm to melt it. Shell lac is excellent for fastening ruby cylinders in watches, and similar delicate purposes.

Broken Glass Solder.—Broken glass is soldered by interposing between the parts, glass ground up like a pigment, but of easier fusion than the pieces to be joined, and then exposing them to such a heat as will fuse the cementing ingredient, and make the pieces agglutinate without being themselves fused.

A glass for cementing broken pieces of flint glass may be made by fusing some of the same kind of glass previously reduced to powder, with a little lead and borax, or with borax only.

Derbyshire Spar Cement, &c.—This cement is made with about eight parts of resin and one of bees' wax, melted together with a small quantity of plaster of Paris. If the cement is to fill up the place of any small chips that may have been lost, the quantity of plaster may be increased a little. When the ingredients are well mixed, and the whole nearly cold, the mass must be well kneaded together. The pieces of spar to be joined, must be heated until they melt the cement, and then pressed together, some of the cement being previously interposed. Melted sulphur applied to fragments of stones previously heated (by placing them before a fire) to at least the melting point of sulphur, and then joined with the sulphur between, makes a pretty firm and durable joining. Little deficiencies in the stone, as chips out of corners, &c. may also be filled up with melted sulphur, in which some of the powder of the stone has been melted.

Steam Cement.—To join the flanches of iron cylinders, and other parts of hydraulic and steam engines, the following methods are adopted by machinists:—Boiled linseed oil, litharge, red and white lead mixed together to a proper consistence, applied on each side of a piece of flannel, previously shaped to fit the joint, and then interposed between the pieces before they are brought home, (as the workmen term it) to their place by the screws or other fastenings employed, make a close and durable joint. The quantities of the ingredients may be varied without inconvenience, taking care not to make the mass too thin with oil. It is difficult in many cases instantly to make a good fitting of large pieces of iron work. This renders it necessary sometimes to join and separate the pieces repeatedly before a proper adjustment is obtained. When this is expected, the white lead ought to predominate in the mixture, as it dries much slower than the red. A workman knowing this fact, can be at little loss in exercising his own discretion in regulating the quantities. It is safest to err on the side of the white lead, as the durability of the cement is not thereby effected, a longer time only is required for it to dry and harden. When the fittings will not easily admit of so thick a substance as flannel being interposed, linen may be substituted, or even paper or thin pasteboard. This cement answers well also for joining broken stones, however large. Cisterns built of square stones, put together with this cement, will never leak, or want any repairs. In this case, the stones need not be entirely bedded in it; an inch, or even less, of the edges that are to be next the water, need only be so treated; the rest of the joint may be filled with good lime.

Another of the same. This cement, preferable even to the former, for steam-engines, is prepared thus:—Take two ounces of sal ammoniac, one ounce of flowers of sulphur, and sixteen ounces of cast iron filings or borings; mix them in a mortar, and keep the powder dry. When the cement is wanted for use, take one part of the above powder, and twenty parts of clean iron borings or filings, and blend them intimately by grinding them in a mortar. Wet the compound with water, and when brought to a convenient consistence, apply it to the joints with a wooden or blunt iron spatula. This is the cement with which the joinings of the Southwark cast-iron bridge were filled up and clasped. Action and reaction take place among the ingredients, and between them and the iron surfaces, which at last causes the whole to unite as one mass. After a time, the surfaces and the mixture become one.

Roman Cement.—By a recent analysis of Parker's Roman cement, by Monsieur Berthier, he finds that its constituents differ so little from the constituents of chalk and common clay, that he proposes the manufacturing of a similar cement by the mere mixture of them in certain proportions.—One part of clay, and two and a half parts of chalk, sets almost instantly, and may therefore be regarded as Roman cement.

Blood Cements, are used by coppersmiths to lay over the rivets and edges of the sheets of copper in boilers of the first class: they also give additional security to the joinings, and secure cocks from leaking. This cement is made by mixing pounded quicklime with oxen's blood: but unless used when fresh made, it will become hard. It is durable, cheap, and extensively applicable in the rougher branches of art.

Flour Paste Cement.—Flour paste for cementing, is formed principally of wheaten flour, boiled in water till it be of a glutinous or viscid consistence. It may be prepared of these ingredients simply for common purposes, but when it is used by bookbinders, or for paper hanging, it is usual to mix with the flour a fifth or sixth of its weight of powdered alum; and where it is wanted still more tenacious, gum arabic, or any kind of size, may be added.

Rice Glue.—This elegant cement is made by mixing rice flour intimately with cold water, and then gently boiling it. It is beautifully white, and dries almost transparent. Papers pasted together with this cement will sooner separate in their own substance than at the joining, it is therefore extremely useful in the preparation of curious paper articles, as tea trays, ladies' dressing and work boxes, and other articles which require layers of paper to be cemented together. In every respect it is preferable to common paste made with wheat flour. It answers well for pasting into books the copies of writing taken off by copying machines on unsized silver paper. With this composition, made with a small quantity of water, that it may have a consistence similar to plastic clay, models, busts, statues, basso relievos, and the like, may be formed. When dry, the articles made of it are susceptible of a high polish; they are also very durable. The Japanese make quadrille fish of this substance, which so nearly resemble those made of mother of pearl, that the officers of our East Indiamen are often imposed upon.

Of Sizes.—Common size, manufactured in the same manner, and generally by the same people as glue, is glue left in a moister state, by discontinuing the evaporation before it is brought to a due consistence.'

Isinglass Size, is prepared much in the same way as glue; the quantity of water for dissolving it is increased; and the same makes good parchment size.

CENOTAPH, an empty tomb erected in honour of a deceased person, and is thus distinguished from the sepulchre in which a coffin is deposited.

CENTAURUS, *the Bull Pricker*, as his name denotes, ranks among the old constellations. The Centaur is said to derive its name from those sons of Ixion and Nubes, whom fable represented half men, half horses; and the notions which the Americans entertained of the Spanish cavaliers, have been suggested, to persuade us that the ancients who first saw a man on horseback, conceived him and the animal to be one. The fable of the Centaurs and the *Lapithæ*, is well known to every schoolboy. The boundaries and contents of this constellation are: on the north by Hydra, east by Lupus, south by Crux, and west by Robur Caroli. There are thirty-five stars in this constellation, *viz.* two of the 1st magnitude, one of the 2d, six of the 3d, nine of the 4th, &c. The brilliants of this constellation are situated on the feet of the Horse; and with the adjoining asterism of the Cross, make a very splendid shew in southern latitudes; but the people of Britain are too far north to enjoy this sight. The star β, in the western foot, culminates about 7 minutes before α, or at XIX ho. 1′ 45″, on the 1st of January, and by making an allowance of about 4 minutes for each succeeding day of the month, it will be on the meridian, January 2, at XVIII ho. 57′ 21″, on the 3d at XVIII h. 52′ 58″, on the 4th at XVIII ho. 48′ 38″, &c.

CENTESM, the 100th part of a thing.

CENTRAL, something relating to a centre. Thus, we have CENTRAL *Eclipse*, CENTRAL *Force*, &c. Central Eclipse is, when the centres of the luminaries exactly coincide, and are directly in a line with the eye of the observer. Central Forces are those forces which tend directly to or from a certain point or centre; or they are forces which cause a moving body to tend towards, or recede from, the centre of motion; and are hence divided into two kinds, according to their different relations to the centre, *viz.* whether it be to approach or to recede from it; being called, in the former case, *centripetal* force, and in the latter, *centrifugal*. *See* FORCE.

CENTRE, in a general sense, denotes a point equally remote from the extremes of a line, surface, or solid. The word signifies a point.

CENTRE *of an* ARCH. Under the word *Bridge*, the various forms of arches were noticed. We will now shew how the archstones are supported till the arch is completed; and the most commodious and least expensive manner in which this can be accomplished.

1. When the span is small, as cellars and vaults, the foundation of the side wall is dug out, the earth rounded over upon it, the arch thrown, and the earth afterwards dug away.

2. When it is necessary to use wood for the frame or centre, we must *first* consider the weight to be supported; *secondly*, the quantity of materials to be used, that shall be of sufficient strength to support such a weight; and, *thirdly*, the most effective method to apply these materials.

First, the Weight to be supported.—A semicircular arch can be raised 30 degrees, (see *Bridge*,) without a centre. There are 120 degrees to support; and if the diameter be 20 feet, 120° will measure 20·91393 + feet; say 21 feet. The keystone of such an arch would be driven at 18 inches depth. The specific gravity of a cubic foot of hard stone, is 2·532. A stone 18 inches square, by 21 feet, gives 47·25 solid feet: the weight by the above specific gravity is 7477·307 lbs, or 66·753 cwt. being the weight that one rib of the centre frame must sustain.

In the span of 50 feet, the arch of 120° measures 52·36 feet; the archstone is 2½ feet deep by 2 feet, is 5 superficial feet, which + 52·36 = 261·8 solid feet and 369·908 cwt. of specific gravity. Here the weight is increased upon the centre frame in the proportion of 66·5 to 309·9; or more than five times, for the difference of the centre framework.

In the span of 100 feet, arch 104·719 feet, keystone 4 × 3, we have 1256·628 solid feet, 1775·848 cwt. specific gravity; above five times the weight of an arch of 50 feet span. In the span of 130 feet, the arch 156·13556 feet, the arch 5 × 3, as in the bridge of Dee at Aberdeen, we have 2042·0336 solid feet, and 2885·2838 cwt. the rib or beam of the frame centre. *See* STRENGTH OF MATERIALS.

Secondly, the strength of timber requisite to support any of the foregoing weights may be ascertained thus:—In all mechanical structures, each member should not only be able to resist the strain under which it is constantly subjected, but should also be able to withstand those occasional shocks to which it is ever exposed. This is peculiarly the case in the framing of centre work for bridges. Every piece of wood employed is of a prismatic or columnar form, and is exposed either to longitudinal or transverse strain; and may be so used as to sustain a longitudinal tension, in withstanding a longitudinal compression, in resisting a transverse pressure, and in opposing the act of twisting or wrenching. But the investigation of these topics would interest few readers, and to those few the results would not be of much practical value.

A batten or prism of wood, 5 inches square, and 14 feet long, supports a weight of 5300 lbs. which may be called its breaking weight; and it has more than double the strength of a prism of 28 feet long, 5 inches square, for 1775 lbs. would break the latter. Every beam of wood becomes more liable to break by its length; 12 inches, 5 inches square, weight 10·4 lbs. more or less; and 10·4 lbs. at 13 feet distance, acts with a power of 135·2 lbs. This is the last term, and 0, the point of fracture, is the first term. The first and last multiplied by half the number of terms = the sum of all the terms; or 135·2 × 6½ = 878·8 lbs. added to 1775 = 2653·8, being very near the half of the force that breaks the prism of 14 feet. The weight that breaks a prism of 9 feet long and 5 inches square, is 8308. To reduce this experiment to one of greater dimensions, suppose one foot; similar solids of the same altitude are to one another as their bases; *i. e.* 25, the base of the 5 inch square is to 144, the base of 1 foot square, as the weight that would break the batten of 9 feet, to the weight that would break the batten of the same length and 12 inches square; that is, the base 25 : 8308 : : 144 : 47854 lbs. = 213·8125 tons; and the proportion, as above, for greater or less length of logs or spars. And a batten of any depth, and one half breadth, is equally strong in that position as if it had been square timber: hence the advantage in point of economy; for if the piece is set upon edge, suppose 9 inches deep and one broad, provided it receives no lateral tension, it will bear as much strain as if 9 inches square. In general, a beam the same length and breadth as another, but twice the depth, is four times stronger; and a beam of the same depth and breadth, and double the length, is only half so strong. These experiments were made upon well-seasoned oak; but between one-third and one-half of the absolute strength of these results will do in practice.

We are now, in the *third* place, to consider *the most effective method of applying these materials.* The late Mr. Rennie found, that cubes of one inch are crushed by the weights annexed:—

Elm,	1·284 *lbs.*
White deal,	1·928
English oak,	3·860
Craigleith freestone,	8·688

Cubes of 1½ inch are, however, crushed with less loads in proportion: thus,

Red brick,	1·817 *lbs.*
Yellow baked brick,	2·254
Fire brick,	3·864
Craigleith stone,	15·560
White statuary marble,	13·632
Purbeck limestone,	20·610
Cornish granite, of which Waterloo Bridge was built,	14·302
Peterhead granite,	18·636
Aberdeen blue granite,	24·536

A pillar in the church of All Saints, at Angers, is 24 feet high and 11 inches square, supporting 60,000 lbs. which is not one-seventh of the weight that would crush it. Hence the delicacy of many pillars in Gothic buildings, and of those in the Exchange, Cornhill, London. Instead of a pier of 10 feet in a bridge of 50-feet span, one of 2 feet thick would be sufficient. How superfluous then are those enormous piers that obstruct the course of rivers.

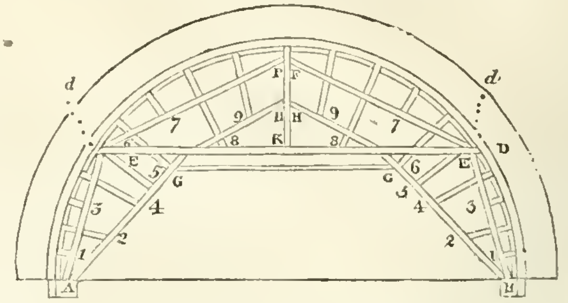
But the inquiry is with wood; and to arrive at our conclusion, let us consider precisely the strength of an arch above a right line parallel to the horizon. An arch recedes from a perpendicular to a horizontal line, the force therefore that it will sustain, is, between the force that a body will carry in the perpendicular, and that which produces a fracture upon any material in the horizontal direction. If the perpendicular is greater than the horizontal line, it will have more of the strength of the bruising force, than of the transverse fracture. This force is explained by the ratio compounded of the bruising force and that of the transverse fracture, *i.e.* the absolute and relative force. In other words, if a geometrical mean be taken between the elevation of the arch, as pressure of absolute strength, and the length of the horizontal line, this mean will be the strength of the arch above the horizontal line.

Experiments made upon prisms of seasoned oak, 2 inches square, and 2, 4, or 6 feet high, shewed them crushed by the vertical pressures of 17,500 lbs. 10,500 lbs. and 7000 lbs.; but if 4 inches square, and of the same altitudes, they would give way under loads of only 80,000 lbs. 70,000 lbs. and 50,000 lbs. In the first set of trials, the mean cohesive power amounts to 130,000 lbs. and in the second to 520,000 lbs.

From all these reasonings it appears, that so much as the piece of wood is elevated towards the perpendicular, so much the nearer it approaches to its absolute strength, and by so much as the arch is flatter, or the piece of wood less inclined, the nearer it is to a straight line, and so much the more reduced to its relative strength; the position of the arch therefore must be in the ratio compounded of these two.

Having established these principles, let us now shew the application in practice.

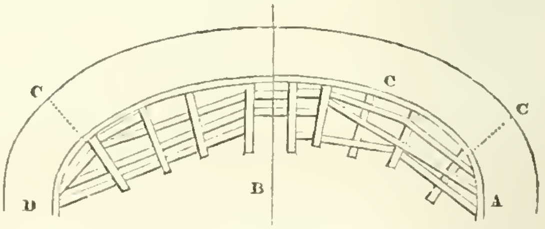
Pitot's plan of an arch, as represented in the following figure, though profuse in materials, possesses great ingenuity. The arch A C D B can be raised 30° on each side, or to the point D, without any centre. The stretcher E E is now raised and propped by the struts A E, B E. The stretcher E E is divided into four equal parts; at the centre part the king post K F rises the height of the intended arch. The struts A G, B G, and the tie beam G G, are previously put in; G G being one-half of E E. The bridles, 1, 2, 3, 4, &c. prevent the arch from yielding from A to C, or from B to D. The struts A C, B D, support the bridles 1, 1; 3, 3;—the struts B G, A G, support the bridles 2, 2; 4, 4; 5, 5; 6, 6,—the struts E P, D F, support the bridles 7, 7;—the struts G H, G H, support the bridles 9, 9; and the bridles 8, 8, rest on the stretcher E E. The struts E P, D F, support the king post, as do also the struts G H, G H, and the king post being well secured to the stretcher E E, supports it in the centre.



This arch we will say is 60 feet span, the archstones 7 feet long, and 3 feet broad, each cubic foot of which is 160 lbs. Let the structure be of Portland stone, which weighs 160 lbs. the cubic foot. The stretcher E E may be raised 45° in the place of 30° before the centre is put up. Therefore there are only 90° of arch to provide for, and the perpendicular *d*, D *d*, determines the limits of the absolute pressure upon the frame. The parts of the arch below C and D rest upon the abutments of the pier. And the weight of one course of the archstones is 53 × 7 × 3 = 178,080 lbs. But the absolute transverse strength of a plank 7 feet long and 12 inches broad, by one thick, is 189,163 lbs.; or if 2 inches thick, it would be no more. A plank 7 feet long and 8 inches square, has 47,649 lbs. of transverse strength. Therefore, the former species of scantling is the better, as it gives us an excess of 11080 lbs. more strength than is required to support that part of the arch. But 7 feet is only one-seventh part of 53 feet, the frame is therefore of sufficient strength to support the whole weight of the arch when equally divided along its whole length.

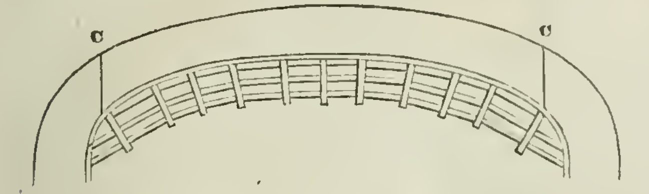
The relative proportion of the strength of oak and fir is $\frac{4}{10}$, therefore for every beam 8 inches square of oak, 9½ by 2½ of fir may be used.—From these principles of M. Pitot, every mechanic may construct the frame centre for any bridge.

In the centering of the *Bridge of Carrin*, as represented in the following figure, the arches are elliptical, the longer axis or span is 60 feet, the semitransverse axis or rise 20 feet, the archstones weigh 176 lbs. per cubical foot, and are 4 feet in length, which is the thickness of the arch; the truss beams were from 15 to 18 feet long and 9 inches by 8 inches broad, *of* oak. There were five trusses 5½ feet asunder, and the whole weight of the arch amounted to 600 tons, or 112 tons for each truss; 90 tons actually pressed on each truss. But the diagonal of the parallelogram of forces drawn for these beams, is to one of the sides as 360 to 285; then 360 : 285 : : 90 : 17¼ tons on each foot or section of 144 inches. And since every square inch of oak can bear 3 tons, there were 431 tons of strength, more than six times the pressure upon the foot beams in their longitudinal direction.

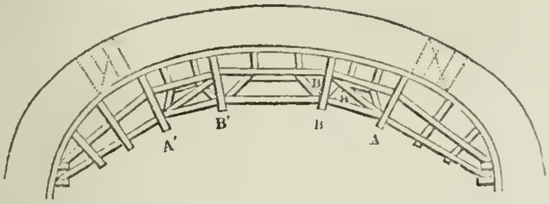


In the section A C B of this figure, we have given the centering used in erecting the bridge of Nogent, and in the section D C B that used in the bridge of Maxence. They differ very little; but the arch of Maxence sunk 13 inches, either from the suppleness of the frame, or because the branches were not filled up as the work proceeded. The centre of Nogent would make a good arch for a wooden bridge, and the joints may all be secured by dove-tailed pieces; and the whole may be kept up at a trifling annual expense.

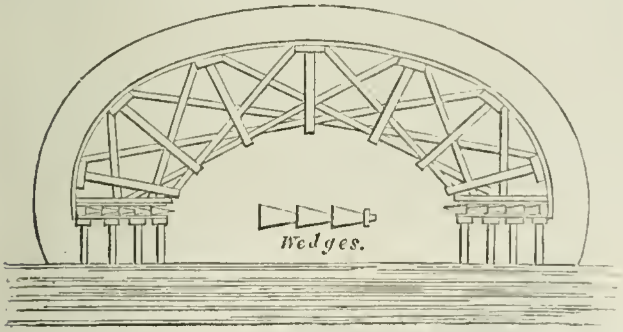
In the *Bridge of Neuilly*, in the following figure, the span of 120 feet has a rise of 30 feet; the arch is 5 feet thick; the strut beams 17 × 14 inches; the king post 15 × 9 inches; the strut beams placed in the parallel to polygons, each abutting on the king post 9 inches square.



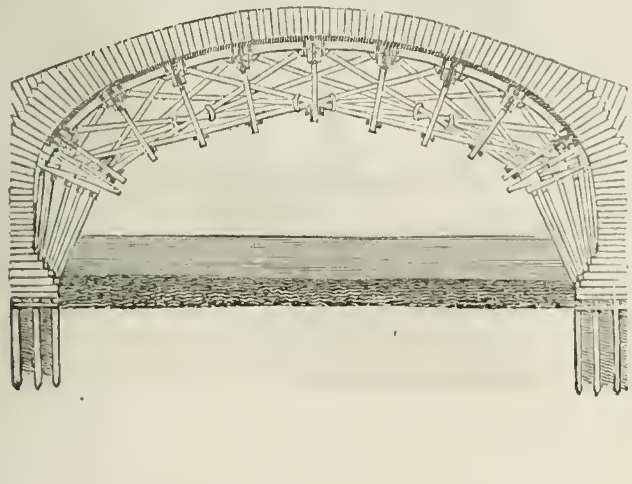
In the *Bridge of Orleans*, in the subjoined figure, span 100 feet, rise 30 feet, the struts A, B; A′ B′, give great additional strength to the centre.



In *Blackfriars' Bridge*, in the following figure, the span is 100 feet, the form elliptical, the archstones at the branch 7 feet, and decreasing to the keystone. This bridge sunk only 1⅜ inches throughout, whereas all the French bridges we have mentioned sunk 11 inches upon an average.



Waterloo Bridge.



The last figure represents the centering used in the construction of Waterloo Bridge, some further details of which we have reserved for the word Iron Bridge.

Centre of a *Conic Section*, is that point which bisects any diameter, or that point in which all the diameters intersect each other. This point in an ellipse is within the figure, in the hyperbola without, and in the parabola it is at an infinite distance.

Centre of *Conversion*, in Mechanics, a term whose signification may be thus conceived:—If a stick be laid on stagnant water, and drawn by a thread fastened to it, so that the thread makes always the same angle with it, the stick will be found to turn about a certain point; which point is called the *centre of conversion*.

Centre of a *Curve*, of the higher kind, is the point where two diameters concur; and when all the diameters concur in the same point, it is called the *general centre*.

Centre of a *Dial*, is that point where the gnomon or style, which is placed parallel to the axis of the earth, intersects the plane of the dial.

Centre of an *Ellipse*. *See* Centre of a *Conic Section*.

Centre of *Equant*, in the old Astronomy, a point in the line of aphelion; being as far distant from the centre of the eccentric towards the aphelion, as the sun is from the centre of the eccentric towards the perihelion.

Centre of *Equilibrium*, is the same with respect to bodies immersed in a fluid, as the centre of gravity is to bodies in free space; or it is a certain point on which if a body, or system of bodies, be suspended, they will rest in any position.

Centre of *Friction*, is that point in the base of a body, on which it revolves; into which, if the whole surface of the base and the mass of the body were collected, and made to revolve about the centre of the base of the given body, the angular velocity destroyed by its friction would be equal to the angular velocity destroyed in the given body by its friction in the same time.

Centre of *Attraction* of a body, is that point into which, if all its matter was collected, its action upon any remote particle would still be the same, as it is while the body retains its own proper form. Or, it is that point to which bodies tend by their gravity, or about which a planet revolves as a centre; being attracted or impelled towards it by the action of gravity. *The common centre of attraction of two or more bodies*, is sometimes used to denote that point in which, if a particle of matter were placed, the action of each body upon it would be equal, and where it will therefore remain in equilibrio; having no tendency to move one way rather than another. This is more properly termed, by some authors, the point of equal attraction.

Centre of a *Circle*, is that point in a circle which is equally distant from every point of the circumference, being that from which the circle is described.

Centre of *Gravity* of any body, or system of bodies, is that point upon which the body, or system of bodies, acted upon only by the force of gravity, will balance itself in all positions; or it is a point which, when supported, the body or system will be supported, however it may be situated in other respects. Hence it follows, that if a line or plane passing through the centre of gravity be supported, the body or system will be also supported. And, conversely, if a body or system balance itself upon a line or plane, in all positions, the centre of gravity is in that line or plane. In a similar manner it will appear, that if a body rest in equilibrio, when suspended from any point, the centre of gravity of that body or system is in the perpendicular let fall from the centre of suspension; and on these principles depends the mechanical method of finding the centre of gravity of bodies.

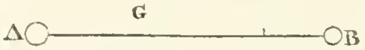
To find the Centre of Gravity of Bodies, mechanically.—For this purpose, it is only necessary to dispose the body successively in two positions of equilibrium, by the aid of two forces in vertical directions, applied in succession to two different points of the body, and the point of intersection of these two directions will shew the centre required.

This may be exemplified by particularizing a few methods

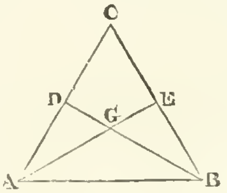
If the body have plane sides, as a piece of board, hang it up by any point, then a plumb-line suspended from the same point will pass through the centre of gravity, therefore mark that line upon it; and after suspending the body by another point, apply the plummet to find another such line, then will their intersection shew the centre of gravity. Or thus: hang the body by two strings from the same point fixed to different parts of the body; then a plummet hung from the same point will fall on the centre of gravity.

Another method: Lay the body on the edge of a triangular prism, or such like, moving it to and fro till the parts on both sides are in equilibrio, and mark a line upon it close by the edge of the prism: balance it again in another position, and mark another line by the edge of the prism; the vertical line passing through the intersection of these lines, will likewise pass through the centre of gravity. The same thing may be effected by laying the body on a table, till it is just ready to fall off, and then marking a line upon it by the edge of the table: this done in two positions of the body, will, in like manner, point out the centre of gravity.

To find the Centre of Gravity of certain Bodies, geometrically.—Prop. 1. To find the centre of gravity of two given bodies. Let A and B be the two given bodies, take A G : B G : : B : A; so shall G be the centre of gravity of the two bodies, as is obvious from the principle of the lever; for the bodies being suspended on the point G, they will remain in equilibrio.—In other words, the distances A G, B G, from the common centre of gravity, are reciprocally as the weights of the bodies A and B; for, if A G = 4, B G = 6, and the ball B = 2, then the ball A = 3, because 4 : 6 : : 2 : 3.

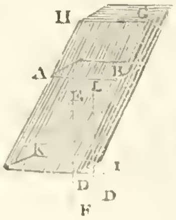


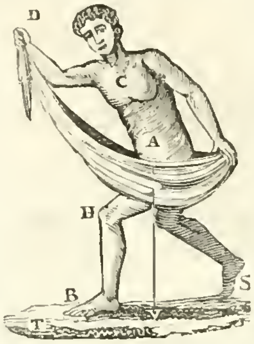
Prop. 2. To find the centre of gravity of a triangle, A B C. Bisect any two sides, A C, C B, in the points D and E, join A E, B D, and the point of intersection G will be the centre of gravity of the triangle. This is obvious, because the triangle would balance itself on each of the lines A E, B D; for these bisecting the line B C, A C, bisect every parallel section, and therefore the weight on each side is equal, and equally distant from these lines.



3. To find the centre of gravity of a trapezium. Divide it into two triangles, and find the centre of gravity of each; and then, by prop. 1, the centre of gravity of these two, which will be the centre of gravity of the trapezium. And in the same manner may be found the centre of gravity of any right-lined figure.

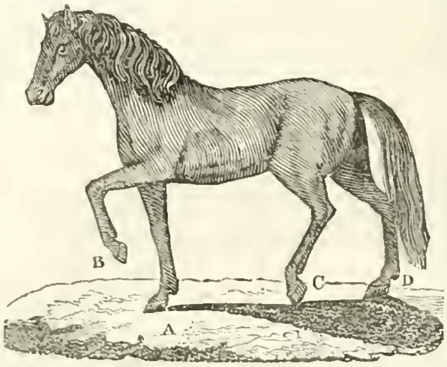
When from the centre of gravity of any body we let fall a line perpendicular to the horizon, that line is called *the line of direction*, the property of which is, that when it falls within the base upon which the body stands, the body cannot fall, but if it falls *without* the base, the body will tumble. Thus, in the inclining body A B, C D, as in the annexed figure, the centre of gravity is E, and the body stands firmly on its base, C D I K, because the line of direction E F falls within the base. But if the weight, as A B, G H, be laid upon the top of the body, the centre of gravity is raised to L; and then, as the line of direction L D falls without the base at D, the centre of gravity L is not supported, and the body and weight will tumble. Hence is obvious the danger of rising hastily in a coach or boat, when it is likely to overset. By so doing, the centre of gravity is liable to be thrown out of the base, and the vehicle or boat overset. The proper conduct of passengers in such circumstances is to lie down in the bottom, and bring the line of direction, and consequently the centre of gravity, within the base. Coaches are now built so as to confine the centre of gravity within the base upon the most uneven roads. The mechanical motions of animals ought to be regulated on these principles; for when the line of direction falls within the base of our feet, we stand, and most firmly, when it is in the middle of the body, as A, in the human figure; but when it is out of the base, we immediately fall. When you endeavour to rise from a seat, you thrust forward your body, and draw your feet backward, till the vertical line from the centre of gravity falls just before your feet; this enables you to rise, and prevents you falling forward; you advance one of your feet, till the vertical line of direction is brought between your feet, in consequence of which you may stand firmly. When a man, B C, as shewn in the following figure, endeavours to walk, he first extends his hindermost leg and foot, S, almost to a straight line, and at the same time bends a little the knee, H, of his fore leg. Thus his hind leg is lengthened, and his fore leg shortened, and by this means his body is moved forward, till the centre of gravity, V, falls beyond the fore foot B; and then being ready to fall, he presently prevents it, by taking up the hind foot, and by bending the joints of the hip, knee, and ancle, and suddenly translating it forward to T beyond the centre of gravity, and thus he gains a new station.





After the same manner, by extending the foot and leg H B, and thrusting forward the centre of gravity beyond the foot S, and then translating the foot B forward, he gains a third station; and thus walking is continued at pleasure. His two feet do not go in one right line, but in two lines parallel to one another; therefore, a man walking has a libratory motion from one side to the other; and it is not possible to walk in a right line. We walk on level ground easily and pleasantly; it is laborious to climb a hill, from the great flexure required of the joints to ascend, and from the stress they receive from the weight of the body in that position. In *walking* we always set down one foot before the other be taken up; and therefore at every step we have both feet on the ground at once. But in *running* we never set one foot down till the other be up; so that at every step we have but one foot on the ground, and all the intermediate time none. The walking of birds is not unlike that of man; only their weight is entirely supported by the strength of the muscles, since their joints are always bent. The feet of birds are also moved in two parallel lines. The motions of quadrupeds are the same as those of men.

When a *beast*, a horse for example, *stands*, the line of gravity must fall within the quadrilateral made by his four feet. When he *walks*, he has always three feet on the ground, and one up, as you see in the figure. Thus, suppose he first lift the hind foot C. Before he does this, by extending his leg backwards, he thrusts forward his body and the centre of gravity; then taking up the foot C he moves it forward to F. Then he directly takes up the fore foot B on the same side, and carries it to H; then he takes up the hind foot D, and translates it forward; and then the fore foot A; then C again, and so on.



Let any person try to walk on all-fours, and one hand and one leg on one side, one hand and one leg on the other, is the natural action of the horse in walking. When the horse *trots*, he takes up two feet together, and sets down two together, diagonally opposite. When he *gallops*, he takes up his feet one by one, and sets them down one by one; though some animals strike with the two fore feet nearly at once, and the two hind feet nearly at once; and have not above two feet on the ground at once. Animals of six or more feet, as the caterpillar, take up the hindmost first, then the next, and then the next in order to the foremost, *all on one side;* and after that, all the feet *on the other side;* in the same order, beginning at the *last.* If the caterpillar were to take up its foremost feet first, it would move backwards, as we see a crab do on the sea-horse.

Dogs, and other four-footed animals, find it difficult to stand upon their hind legs, as the centre of gravity lies too far forward, the heads of all animals being heavy, in proportion to other parts of the body.

In the duck, the goose, and the swan, who are adapted for swimming, the centre of gravity lies pretty far forward; hence they walk awkwardly, and do not seem at ease but when in the water. Hawks have the centre of gravity so far forward, that when they light on the rocks they are obliged to stand with their heads up, somewhat in the manner of dogs. If they were to put themselves in any other position, they would fall forward. Penguins are similarly formed, and their weight sinks them so deep in the water, that a stream passes between the neck and the body. In cats, and animals that spring upon their prey, the centre of gravity is so situated that they uniformly fall upon their feet. When dropping from a height, they hang down the fore and hind feet and tail, so as to bring the centre of gravity to the point below their breast, which, descending first, makes them fall as they do. Fasten a piece of lead or stone to the string of a bent bow, and toss the whole in the air, that part will come down first, and the back of the bow will never do so. The same cause acts in the case of cats and other animals of prey.

We are told by voyagers, and writers on natural history, that tortoises are taken in warm climates whilst floating in a drowsy state on the surface of the waves. A man throws himself out of the boat, and lays hold of the tortoise by the tail, and by his weight keeps it from diving, which gives his companions time to lay hold and drag it into the boat.

Centre of *Gyration*, of a body, or system of bodies, is that point into which, if the whole mass were collected, a given force applied at a given distance from the axis of suspension, would produce the same angular velocity in the same time, as if the bodies were disposed at their respective distances. This point differs from the centre of oscillation only in this, that in the latter case the motion is produced by the gravity of the body or of its particles, but in the case of the centre of gyration the body is put in motion by some other force acting at one place only. The distance of the centre of gyration from the axis of motion, is a mean proportion between the distance of the centre of gravity and oscillation from the same axis. Hence, when any two of these distances are known, the third may be readily determined.

Centre of *Magnitude*, the point equally distant from the similar external parts of a body.

Centre of *Motion*, that point which remains at rest while all the other points of a body move about it. And this is the same in uniform bodies of the same matter throughout, as the centre of gravity.

Centre of *Oscillation*, is that point in the axis of suspension of a vibrating body, in which if all the matter of the system were collected, any force applied there would generate the same angular velocity in a given time, as the same force at the centre of gravity, the parts of the system revolving in their respective places. Or, since the force of gravity upon the whole body may be considered as a single force, equivalent to the weight of the body, applied at its centre of gravity; the centre of oscillation is that point in a vibrating body, into which if the whole mass were concentrated, and attached to the same axis of motion, it would then vibrate in the same time the body does in its natural state. The centre of oscillation cannot fall within a cone, unless the altitude be greater than the semidiameter of the cone's base; and when the altitude and semibase are equal, the centre of the base is the centre of oscillation; but when the semidiameter of the base exceeds the altitude, it always falls below the base.

Centre of *Percussion*, in a moving body, is that point where the percussion or stroke is the greatest, in which the whole percutient force of the body is supposed to be collected; or about which the impetus of the parts is balanced on every side, so that it may be stopped by an immoveable obstacle at this point, and rest on it without acting on the centre of suspension.

1. When the percutient body revolves about a fixed point, the centre of percussion is the same with the centre of oscillation; and is determined in the same manner, *viz.* by considering the impetus of the parts as so many weights applied to an inflexible right line void of gravity; namely, by dividing the sum of the products of the forces of the parts multiplied by their distances from the point of suspension, by the sum of the forces. The centre of percussion in a cylinder is at ⅔ of its length from the point of suspension; or a stick, of a cylindrical figure, supposing the centre of motion at the hand, will strike the greatest blow at a point about two-thirds of its length from the hand.

2. But when the body moves with a parallel motion, or all its parts with the same celerity, then the centre of percussion is the same as the centre of gravity. For the momenta are the products of the weights and celerities; and to multiply equiponderating bodies by the same velocity, is the same thing as to take equimultiples; but the equimultiples of equiponderating bodies do also equiponderate, therefore equivalent momenta are disposed about the centre of gravity, and consequently in this case the two centres coincide, and what is true of the one will hold in the other.

Centre *Phonic*, in Acoustics, is the place where the speaker stands in polysyllabical and articulate echoes.

Centre *Phonocamptic*, is the place or object that returns the voice.

Centre of *Position*, in Mechanics, denotes a point of any body, or system of bodies, so selected that we may properly estimate the situation and motion of the body, or system, by those of this point. It is evident, that in mechanical discussions, the point, by the position of which we estimate the position and distance of the whole, must be so determined that its position and distance of the whole, estimated in any direction whatever, shall be the average of the positions and distances of every particle of the mass estimated in the same direction. Accordingly, this will be the case, if the point be so selected that when a plane is made to pass through it in any direction whatever, and perpendiculars are drawn to this plane from every particle in the body or system, the sum of all the perpendiculars on one side of this plane is equal to the sum of all the perpendiculars on the other side.

Centre of *Pressure*, or *Meta Centre* of a fluid against a plane, is that point against which a force being applied equal and contrary to the whole pressure, it will sustain it, so as that the body pressed on will not incline to either side. This is the same as the centre of percussion, supposing the axis of motion to be at the intersection of this plane with the surface of the fluid; and the centre of pressure upon a plane parallel to the horizon, or upon any plane where the pressure is uniform, is the same as the centre of gravity of that plane.

Centre of *spontaneous Rotation*, is that point which remains at rest the instant a body is struck, or about which the body begins to revolve. If a body of any size or form, after rotatory or gyratory motions, be left entirely to itself, it will always have three principal axes of rotation, that is, all the rotatory motions by which it is effected may be constantly reduced to three, which are performed round three axes perpendicular to each other, passing through the centre of gravity, and always preserving the same position in absolute space, while the centre of gravity is at rest, or moves uniformly forward in a right line.

Centre *Velic*, *Velique*, or *Velic Point*, is the centre of gravity of an equivalent sail, or that single sail whose position and magnitude are such as cause it to be acted upon by the wind when the vessel is sailing, so that the motion shall be the same as that which takes place while the sails have their usual positions.

CENTRIFUGAL Pump, a very curious machine for raising water by means of a centrifugal force combined with the pressure of the atmosphere. It consists of a large tube of copper, &c. in the form of a cross, which is placed perpendicularly in the water, and rests at the bottom on a pivot. At the upper part of the tube is an horizontal cog-wheel, which touches the cogs of another in a vertical position; so that by the help of a double winch the whole machine is moved round with very great velocity. Near the bottom of the perpendicular part of the tube is a valve opening upwards; and near the two extremities, but on the contrary side of the arms or cross part of the tube, are two other valves opening outwards. These two valves are, by the assistance of springs, kept shut till the machine is put in motion, when the centrifugal velocity of the water forces them open, and discharges itself into a cistern or reservoir placed there for that purpose. On the upper part of the arms are two holes, which are closed by pieces screwed into the metal of the tube. Before the machine can work, those holes must be opened, and water poured in through them, till the whole tube be full; by these means all the air will be forced out of the machine, and the water supported in the tube by means of the valve at the bottom. The tube being thus filled with water, and the holes closed by the screw-caps, it is turned round by means of the winch, when the water in the arms of the tube acquires a centrifugal force, opens the valves near the extremities of the arms, and flies out with a velocity nearly equal to that of the extremities of the said arms. This machine cannot raise water higher than 32 feet; because its action depends upon the weight of the atmosphere, and, on shipboard, is much inferior to the chain-pump.

Centrifugal *Force*, is that force by which a body revolving about a centre, or about another body, has a tendency to recede from it.

CENTRIPETAL Force, is that force by which a body is perpetually urged onwards to a centre, and thereby made to revolve in a curve instead of a right line.

CENTURY, any thing divided or ranged into periods of hundreds. Thus we say, such a century of the Christian æra, meaning so many hundred years since the commencement of that æra, and which is necessarily one more than the number of years mentioned in the date: the present is the 19th century, which commenced on the 1st of January, 1801.

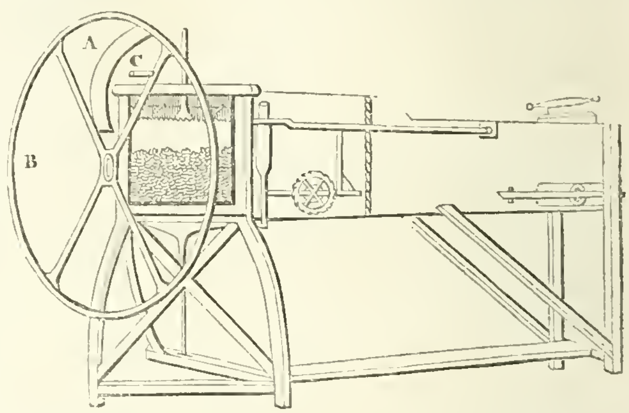
CEPHEUS. This constellation perpetuates the memory of an ancient king of Ethiopia, or India, said to be the father of Andromeda, and husband of Cassiopeia. *Hyk* (a king) was the old Ethiopian name for this asterism, which the Arabians call *Keiphus*, and *Cheic*, an evident corruption from the Greek.—The boundaries and contents are: north by the pole of the world, east by Cassiopeia and Tarandus, south by Lacerta and Cygnus, and west by Draco. Right ascension 8°, and declination 69° north. It contains 35 stars, *viz.* three of the 3d magnitude, seven of the 4th, &c. Alderamin, *a*, having 318° 33′ 55″ right ascension, and 61° 49′ 28″ north declination, culminates, at London, on the first day of every month, as shewn in the following table: Meridian Altitude 79° 41′ 32″ north.

Month.	Culm.	Month.	Culm.	Month.	Culm.
	ho. mi.		ho. mi.		ho. mi.
Jan.	2 36 A.	May	6 34 M.	Sept.	10 29 A.
Feb.	12 19 A.	June	4 39 M.	Oct.	8 44 A.
March	10 19 M.	July	2 39 M.	Nov.	6 59 A.
April	8 29 M.	Aug.	12 29 M.	Dec.	4 49 A.

CETUS, *the Whale*, is pretended by the Greeks to be the sea monster which Neptune, brother to Juno, sent to devour Andromeda, because her mother, Cassiopeia, had boasted herself to be fairer than Juno and the Nereides; and it was placed among the stars, when Perseus, to save that princess, struck it dead, by presenting to its view the head of Medusa. The name of this constellation is found long prior to the time of Perseus. When the equinoctial sun in Aries opened the year, it was denominated the *preserver* or *deliverer*, by the idolaters of the East. The constellation of the Whale is called *Nun* in Chaldaic, and *Nuna* in Syriac. Now the head of Cetus is placed immediately under the *Ram*, and always rises and sets with that sign, but the rest of the constellation rises before Aries. On this account, it has been suggested, that the *Ram* was metaphorically called the son of that constellation, which is next to it, and which rises immediately before it.—The boundaries and contents of this constellation are: north by Pisces and Aries, east by Eridanus, Orion, and Taurus, south by Fornax Chemica and Officina Sculptoris, and west by Aquarius. This constellation occupies the greatest space of any in the firmament. It contains 97 stars, of which two are of the 2d magnitude, eight of the third, nine of the 4th, &c. The brilliant in this constellation is *Menkar*, situated in the upper mandible, and of the 2d magnitude, having 43° 12′ 59″ north, right ascension, and 3° 22′ 50″ declination north. This star appears in the horizon, at London, on E. by N. ½ E. point of the compass, and rises and culminates as in the following table: Meridian Altitude 41° 51′ 50″.

Month.	Rises.	Culm.	Month.	Rises	Culm.
	ho. mi.	ho. mi.		ho. mi.	ho. mi.
Jan.	2 0 A.	8 5 A.	July	1 55 M.	8 10 M.
Feb.	11 45 M.	5 53 A.	Aug.	11 50 A.	6 5 M.
Mar.	9 35 M.	4 4 A.	Sept.	9 55 A.	4 10 M.
April	7 50 M.	2 15 A.	Oct.	8 10 A.	2 26 M.
May	6 0 M.	0 20 M.	Nov.	6 15 A.	12 35 M.
June	3 50 M.	10 14 M.	Dec.	4 15 A.	10 22 A.

CHAFF MACHINE, as represented in the following figure, is used for cutting straw for horses and cattle. This machine consists of a wooden frame, supported by four legs, and on this frame is a box to hold the straw, about 5 feet long and 10 inches broad. On the wheel B is fixed a knife A, and in every revolution of the wheel the knife passes the end of the box, and cuts the straw into chaff. The straw is fed by two rollers connected with the machinery in the side of the box, and worked usually by a wheel, whose teeth work in an endless screw. The whole is worked by the hand, which grasps the winch C. This is Baker's chaff-cutter. Pike's is somewhat different.



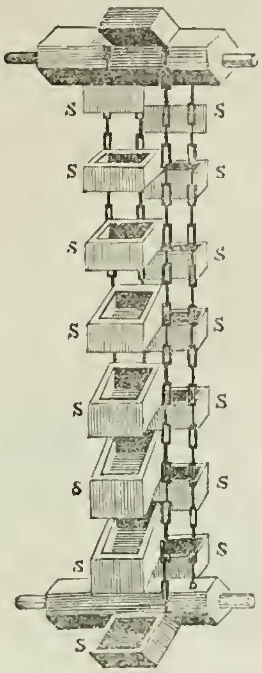
CHAIN, an instrument used in surveying, of which there are three different kinds, but that which is most commonly employed for this purpose, is the *Gunter chain*, so called from the name of its inventor. This chain is 4 poles, or 66 feet long, and is divided into 100 square lengths, or links, each link being 7·92 inches in a link. 1 square chain = 10000 links = 16 poles; 10 square chains = 100000 links = 160 poles = 1 acre.

Hence we have the following easy method of converting links or chains to acres:—From the number of links point off five figures to the right hand for decimals, and those on the left will be acres; multiply the decimals by 4, and point off again five places for decimals, and those on the left will be roods; multiply these decimals by 40, and point off the decimals as above, and the figures on the left will be poles, or perches, which is commonly the lowest denominator. *See* Surveying.

CHAIN-PUMP, a well-known hydraulic machine for raising water. It is usually made from 12 to 25 feet in length, and consists of two collateral square barrels, and an endless chain of pistons of the same form fixed at proper distances. The chain is moved round a coarse kind of wheelwork, fixed sometimes at one end, but often at both ends of the machine. The teeth of the wheelwork are so contrived as to receive one half of the flat pistons, and let them fold in; and they take hold of the links as they rise. A whole row of the pistons (which go free of the sides of the barrel by about a quarter of an inch) are always lifting when the pump is at work; and, as this machine is generally worked briskly, the pistons or pallets bring up a full bore of water in the pump. Chain-pumps are wrought sometimes by men turning winches, sometimes by horses, and sometimes by the impulse of a stream of water: they are likewise so contrived, that by the continual folding in of the pistons, stones, dirt, or whatever comes in the way, may be cleared off; they are therefore often used to drain ponds, sewers, and remove foul water, when no other pump could be employed.

Chain-pumps are not merely fixed in a vertical position, but are often inclined; and in the latter case they are in a state of the greatest perfection, or raise the most water, when the breadth of the pallets is equal to their distance from each other, and the plane is inclined under an angle of 24° 21′. The Chinese method of working the chain-pump resembles the operation of the tread-mill.

It is not unusual for chain-pumps to be erected without a barrel to receive the pistons, after the manner represented in the figure. The pallets are converted into square boxes S, S, &c. which are raised by means of hexagonal axles, each side of the hexagon being equal to the distance from box to box; the boxes descend with their mouths downwards, and so enter the water.



Another contrivance for raising water, similar to the chain-pump, is an endless rope, with stuffed cushions hung upon it, which, by means of two wheels or drums, are caused to rise in succession in the same barrel, and to carry water with them. From the resemblance of this apparatus to a string of beads, it is usually called *paternoster-work*. But in this, as well as the chain-pump, the magnitude of the friction is a formidable practical objection.

CHAINS, strong links or plates of iron, the lower ends of which are bolted through a ship's side to the timbers: they are placed at short distances from each other on the ship's outside, as being used to contain the blocks, called dead-eyes, by which the shrouds of the masts are extended.

CHAIN-SHOT, a particular kind of shot, formed by fastening two cannon-balls together with a short chain, and designed to mangle and ruin a ship's sails and rigging.

CHAIN-WALES, or Channels, broad and thick planks projecting horizontally from the ship's outside, beginning abreast of, and continuing somewhat abaft each mast. They are formed to extend the shrouds from each other, and from the axis, or middle of the ship, so as to give a greater security and support to the masts, and to prevent the shrouds from rubbing against the gun-wale. Every mast has its chain-wales, which are either built above or below the second-deck ports in a ship of the line; they are strongly connected to the side by knees bolts, and standards, besides being confined thereto by the chains, whose upper ends pass through notches on the outer edge of the chain-wales, so as to unite with the shrouds above.

CHALDRON, an English dry measure of capacity, mostly used in measuring coals. The chaldron contains 36 bushels, and weighs about 28 cwt. By act of parliament, the Newcastle chaldron is to weigh 52½ cwt., and this is to the London chaldron in the ratio of 15 to 5, which gives 28 cwt. for the London chaldron, as above stated.

CHAMELEON, The, in Astronomy, is a small asterism by the roots of Robur Caroli, at the south pole, and contains ten stars, none of which exceed the 5th magnitude.

CHANCES, an interesting branch of the modern analysis, which treats of the probability of certain events taking place, by contemplating the different ways in which they may happen or fail. The doctrine of chances is a subject of which the ancients seem to have had no idea; the discovery of it is wholly due to the moderns; but, like most other theories, it has grown into a science by such imperceptible degrees, that we can scarcely say to whom we are indebted for the first invention. But the various circumstances and limitations under which events may happen, render it impossible to reduce the laws of chance to a few determined rules and principles, as is done in various other branches of analysis; much must necessarily be left to the judgment of the analyst, and no subject requires more his care and attention. We cannot in this place enter upon the subject further than to observe, that the probability of casting an ace with a single die in one throw is $\frac{1}{6}$, of casting an ace or deuce is $\frac{2}{6}$, and so on. Again, the probability of drawing an ace out of a complete pack of cards is $\frac{4}{52}$ or $\frac{1}{13}$. For there are four aces and 52 cards, or 4 chances for the event happening, and 52 for its happening and failing.

CHANGES, in Mathematics, denote the various arrangements that may take place in the order or situation of a given number of things; and is distinguished from the more general term Permutations, in this; that in the latter there may be any number of things, and any number taken at a time; while in the former, the whole number is always supposed to enter. The whole number of changes that a given number of things n admits of, is equal to the continued product $1.2.3.4. \dots n$; thus

the number of changes of ....6 things $= 1.2.3.4.5.6 \;=\; 720$
7 things $= 1.2.3.4.5.6.7 = 5040$

See Permutation and Combination.

CHANNEL, in Hydrography, the deepest part of a river, harbour, or streight, which is most convenient for the track of shipping; also, an arm of the sea running between an island and the main or continent, as the British channel, &c.

CHARACTERS, in Mathematics, are certain symbols introduced in order to represent either quantities or operations. Algebraical *Characters* are those used to denote operations, equalities, proportions, &c. *See* Algebraical *Definitions*. Astronomical *Characters* are those used to denote the *Aspects*, *Planets*, *Signs*, &c. Geometrical and Trigonometrical *Characters*. *See* Geometry and Trigonometry. Numeral *Characters* are those used to represent numbers.

CHARGE, in Electricity, in a strict sense, denotes the accumulation of the electric matter on one surface of an electric, as a pane of glass, Leyden phial, &c. whilst an equal quantity passes off from the opposite surface.

Charge, in Gunnery, is the quantity of powder and ball, or shot, put into a piece of ordnance, in order to prepare it for execution. Different charges of powder, with the same weight of ball, produce different velocities in the ball, which are in the subduplicate ratio of the weights of powder; and when the weight of powder is the same, and the ball varied, the velocity produced is in the reciprocal subduplicate ratio of the weight of the ball: and thus corresponds both to theory and practice. This, however, is on a supposition that the gun is of an indefinite length; whereas, on account of the limited length of guns, some variation from this law occurs in practice, as well as in theory; in consequence of which it appears, that the velocity of the ball increases with the charge only to a certain point, which is peculiar to each gun, where the velocity is the greatest; and that, by farther increasing the charge, the velocity is gradually diminished, till the bore is quite full of powder. The length of the charge producing the greatest velocity, ought to be about $\frac{3}{8}$ths of the length of the bore. But for several reasons, the length of the charge producing the greatest velocity falls short of this, and the more so as the gun is the larger. From many experiments it has been found, that the length of the charge producing the greatest velocity, in guns of various lengths of bore, from 15 to 40 calibers, is as follows:

Length of Bore in Calibers.	Length of Charge for greatest Velocities.
15	$\frac{3}{13}$
20	$\frac{2}{11}$
30	$\frac{3}{16}$
40	$\frac{3}{20}$

In practice, however, the charge which produces the greatest velocity, is not that which produces the greatest effect, at least in battering down the gates, &c. of fortified places, and in naval actions; for the balls, in these cases, penetrate and pass quite through, and therefore communicate to the objects they strike against, only a part of their momentum.

CHARLES'S Wain, a name given by some old astronomical writers to the constellation *Ursa Major*.

CHART, or Sea Chart, a hydrographical or sea map, for the use of navigators; being a projection of some part of the sea in plano, shewing the sea-coasts, rocks, sands, bearings, &c. Fournier ascribes the invention of sea charts to Henry, son of John, king of Portugal. These charts are of various kinds, the plain chart, Mercator's or Wright's chart, the globular chart, &c. In the construction of charts, great care should be taken that the several parts of them preserve their position to one another, in the same order as on the earth; and it is probable, that the finding out of proper methods to do this gave rise to the various modes of projection.

There are many ways of constructing maps and charts; but they depend chiefly on two principles. First, by considering the earth as a large extended flat surface; and the charts made on this supposition are usually called plain charts. Secondly, by considering the earth as a sphere; and the charts made on this principle are sometimes called globular charts; Mercator's charts resemble a cylinder unrolled; and to these hydrographical maps we more properly give the epithet *chart*.

Plain Charts have the meridian, as well as the parallels of latitude, drawn parallel to each other, and the degrees of longitude and latitude every where equal to those at the equator. And therefore such charts must be deficient in several respects. For, first, since in reality all the meridians meet in the poles, it is absurd to represent them, especially in large charts, by parallel right lines. Secondly, as plain charts shew the degrees of the several parallels as equal to those of the equator, therefore the distances of places lying east and west must be represented much larger than they really are. And, thirdly, in a plain chart, while the same rhumb is kept, the vessel appears to sail on a great circle, which is not really the case. Yet plain charts made for a small extent, as a few degrees in length and breadth, may be tolerably exact, especially for any part within the torrid zone; and even a plain chart made for the whole of this zone will differ but little from the truth.

Mercator's Chart, like the plain charts, has the meridians represented by parallel right lines, and the degrees of the parallels, or longitude, every where equal to those at the equator, so that they are increased more and more, above their natural size, as they approach towards the pole; but then the degrees of the meridians, or of latitude, are increased in the same proportion at the same part; so that the same proportion is preserved between them as on the globe itself. This chart has its name from that of the author, Girard Mercator, who first proposed it for use in the year 1556, and made the first charts of this kind, though they were not altogether on true or exact principles, nor does it appear that he perfectly understood them. Neither, indeed, was the thought originally his own, of lengthening the degrees of the meridian in some proportion; for that was hinted by Ptolemy two thousand years ago. It was not perfected, however, till about the year 1590, when Mr. Wright shewed a ready way of constructing it, by enlarging the meridian line by the continual addition of the secants.

Globular Chart, is a projection so called from the conformity it bears to the globe itself. This is a meridional projection, in which the parallels are equidistant circles, having the pole for their common centre, and the meridians curvilinear and inclined, so as all to meet in the pole, or common centre of the parallels. By which means the several parts of the earth have their proper proportion of magnitude, distance, and situation, nearly the same as on the globe itself; which renders it a good method for geographical maps.

Hydrographical Charts, are sheets of large paper, on which several parts of the land and sea are described, with their respective coasts, harbours, sounds, flats, rocks, shelves, sands, &c.; also the points of the compass, and the latitudes and longitudes of the places.

Selenographic Charts, are particular descriptions of the appearances, spots, and maculæ of the moon.

Topographic Charts, are draughts of some small parts only of the earth, or of some particular place, without regard to its relative situation, as London, York, &c.

CHEMISTRY, investigates the effects of the action of bodies upon each other, with the view of determining their constituent principles, and forming new compounds. The extensive utility of this science is shewn by its immediate connexion with the arts, subservient to the subsistence or the comforts of man. Dyeing, bleaching, tanning, glass-making, the working of metals, &c. are chemical operations. In agriculture its use is very important, because it explains the phenomena of the growth and nourishment of vegetables, and the nature and action of manures, &c. The culinary arts, the arts of baking, brewing, distilling, &c. owe their improvement to chemistry. In medicine, it affords invaluable assistance, by giving the medical man a knowledge of the various substances used as medicines. In short, there is scarcely any art, trade, or manufacture that does not depend, either immediately or remotely, upon a knowledge of this science. Besides, it enlarges the mind, by affording us a more extensive and intimate knowledge of nature, and procures for us some of the most sublime pleasures and rational enjoyments. Before we proceed to the theory, we shall describe the principal processes employed in chemical experiments: these are—

1. Trituration. 2. Sifting. 3. Washing. 4. Filtration. 5. Decantation. 6. Lixiviation. 7. Evaporation. 8. Distillation. 9. Sublimation. 10. Crystallization. 11. Solution. 12. Precipitation. 13. Fusion. 14. Cupellation. 15. Digestion. 16. Saturation. 17. Combustion. 18. Deflagration. 19. Detonation. 20. Operations in the dry way. 21. And in the humid way.

Mechanical Operations for the Division of Bodies.—Trituration, Pulverization, and Levigation, (or the reduction of solids into powders of different degrees of fineness,) are necessary and preliminary operations, previous to the solids being chemically acted upon. Brittle substances are reduced to powder by means of hammers, pestles and mortars, and stones and mullers. The annexed cut represents a pestle and mortar. Fibrous substances, as wood, the horns of animals, elastic gum, and metals, which flatten under the hammer, cannot be reduced to powder by the foregoing methods; for these, files, rasps, knives, and graters, are used.

Sifting. The separation of the finer parts of bodies from the coarser, which may want farther pulverization, is performed by sifting or washing. A sieve consists of a cylindrical band of thin wood, or metal, having silk, leather, hair, or wire, plaited or woven, and stretched across it. Sieves are of different degrees of fineness.

Washing, is employed for procuring powders of an uniform fineness, more accurately than by the sieve; but it can only be used for substances that are not acted upon by the fluid which is used in the washing.

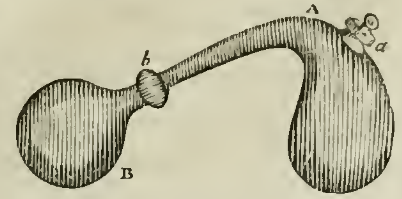
Filtration, is a finer species of sifting, through the pores of paper, flannel, fine linen, sand, pounded glass, porous stones, and the like. It is used for separating fluids from solids, or gross particles that may happen to be suspended in them, and not chemically combined with the fluids. Thus, salt water cannot be deprived of its salt by filtration; but muddy water will deposit its mud.

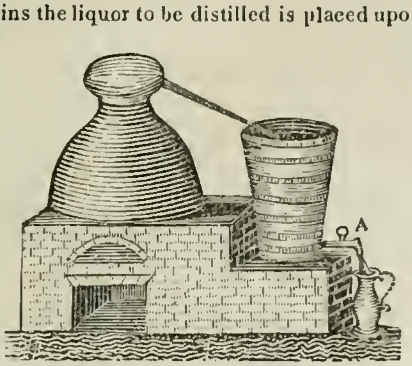
Decantation, separates solid particles which are diffused through liquors. These are allowed to settle to the bottom, and the clear fluid is gently poured off. If the sediment be extremely light, and apt to mix again with the fluid by the slightest motion, a syphon is used for drawing off the clear fluid.

Lixiviation, is the separation by water, or some other fluid, of such substances as are soluble in that fluid, from other substances that are not soluble in it. If a mineral consisting of salt and sand, or salt and clay, &c. be broken to powder and thrown into water, the salt will be dissolved and kept suspended, whilst the earthy matter will fall to the bottom of the vessel, and, by means of filtration, may be separated from the fluid.

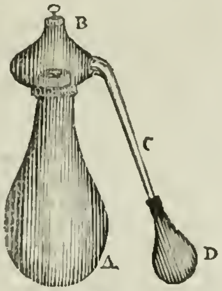
Evaporation, separates a fluid from a solid, or a more volatile fluid from another less volatile. Evaporation is used when the more volatile or fluid substance is not to be preserved, and various degrees of heat are employed for this purpose, according to the nature of the substances. Evaporation is performed in vessels of wood, glass, metal, porcelain, &c. of a flat shape, to expose the liquids as extensively as possible to the action of heat: evaporating vessels may be placed either over the naked fire, or in a vessel filled with sand, called a sand-bath; or they may be left in a warm room.

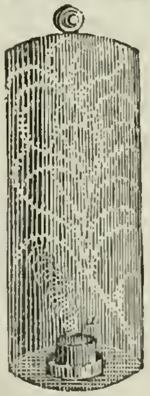
Distillation. When the fluid which is evaporated must be preserved, the operation is called distillation, which is nothing more than evaporation in close vessels, to separate two fluids of different degrees of volatility, and preserve the most volatile, or both of them. The substance to be subjected to distillation is put into some vessel that will resist the action of heat, called a retort. See the annexed figure, of which A is the retort, and B a vessel for receiving the product of distillation; the latter is called the receiver. *a* is called the turbulure, having a glass stopper, by which the substance intended for distillation is poured into the retort; *b* is the neck of the receiver, into which the beak of the retort enters. Alembics and stills having beaks in the same way, are used for sublimation and distillation. The vessel that contains the liquor to be distilled is placed upon the fire, or in a sand bath, or over a lamp; the heat causes the volatile fluid to rise in the form of vapour and pass into the receiver, where it is again condensed by cold. This condensation may be assisted by making the vapour pass through a tube which is immersed in a vessel containing cold water, and called the refrigeratory. The above represents a still in action; A is the end of the tube from whence the distilled fluid escapes.





Sublimation. When the materials which are evaporated concrete in a solid form within the neck of the distilling vessels, the operation is called sublimation, and is performed in an alembic, which the annexed figure represents. A is the cucurbit or boiler; B is the head or capital; C is a glass tube through which the sublimed substances pass into D, the receiver. The following beautiful experiment, illustrated by an engraving, will amply explain the operation of sublimation. Procure a bell-glass, a sprig of rosemary, a flat circular piece of iron or copper, and two drachms of Benzoic acid. Heat the iron nearly to redness, sprinkle the acid on it, and invert the bell-glass, with the rosemary sprig in it, over the whole. The acid will arise or be sublimed in dense fumes, and will be precipitated or settled on the cool branches of the rosemary, in the form of a beautiful hoar frost.



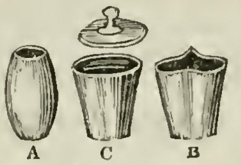


Crystallization. When a salt is dissolved in water, or other fluid, and by evaporation the fluid is driven off, the salt gradually acquires a solid form, and in doing this, it arranges its particles in a particular manner; and they are then said to be crystallized. Some salts arrange themselves in the forms of pyramids, some of prisms of different kinds, &c. Vessels of earthenware or glass are employed for such crystallizations; and they must be kept perfectly still, and well defended from dust or accidents.

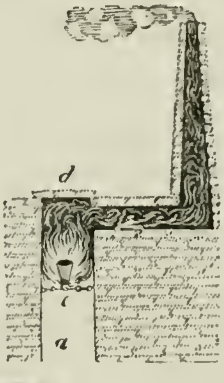
Solution. When a salt is mixed with water, it loses its state of solidity, the particles of salt are divided, and unite themselves to those of the water, forming a liquid of which all the parts are homogeneous, or of the same kind. In this process neither the salt nor the water is decomposed, and the salt may be recovered again in its original state and quantity, by driving off the water by evaporation. The same takes place when resin is mixed with spirits of wine. The solution of metals by acids, is, however, of a different nature; here one of the substances is altered, and different products are obtained. Vessels of glass are used for solution. The liquid used for dissolving a metal, or other solid substance, is usually called a solvent.

Precipitation, is the recovery or separation of a body from its solvent, by the addition of a third substance, so that the former may re-appear in a solid state. The substance thus recovered, is called a precipitate, and the superadded body that occasions this precipitation, is called a precipitant.

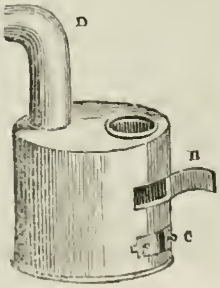
Fusion. The melting or causing any body to pass from the solid to the liquid state, by the action of fire, is called fusion. The fusion of metallic substances requires vessels which will resist destruction by fire. Those vessels called crucibles are mostly, if not always, made of earthenware, or porcelain, or a mixture of clay and powder of black-lead. Some of these are barrel-shaped, as A; others are indented at the side, to allow their contents to be poured out, as B, and others have lids fitted to them, to prevent the sublimation or dispersion of volatile substances, such as arsenic, &c. as C.



Furnaces For fusion, we find it necessary to employ furnaces, or the blow-pipe. The various degrees of heat required for the performance of chemical operations, render a variety of fireplaces or furnaces necessary for a chemist. Furnaces are either open at top, or covered with what is called a dome, and have a chimney or tube to carry off the heated air, smoke, &c. They are sometimes supplied with air from the natural action of the fire, which rarefies the air about the ignited fuel; and which becoming specifically lighter, ascends into the chimney, whilst the colder or heavier air is forced by the atmosphere to enter at the lower part of the furnace. Some furnaces are supplied with air by means of bellows, and those are applied to the forging of iron, or for reducing metals from their ores; this is called smelting. Hence furnaces derive their various names, and are called *simple or open furnaces, reverberatory furnaces, the furnace for distilling by a sand heat, the cupelling or enamelling furnace, and the wind or air furnace,* which the engraving represents; *a* being the ash-pit, *c* the fire containing a crucible, *d* is a moveable cover, to be taken off or put on at pleasure. There are also *blast furnaces, forges, smelting furnaces,* &c.



For common purposes, portable furnaces are used. They are extremely useful for a variety of purposes in the small way; as in distillation, fusion, sublimation, cupellation, &c. &c. In the engraving of one of these furnaces, B is the fireplace, C the ash-pit, and D the chimney.



Blow-pipes are used for diverting the flame of a candle or lamp against any bit of ore or other substance, required to be examined. They ought to have a bulb upon the middle of their stems (according to the figure) to contain the moisture that is formed from the breath. The compound gas blow-pipe, which has been

a late discovery, is perhaps the most generally useful instrument a chemist can possess. *See* Blowpipe.

Cupellation, or the art of assaying metals and ores, is performed in a shallow crucible made of burnt bones. The impure metal or ore is put into the cupel (of which the annexed is a figure) with some oxidizable metal, such as lead. The cupel is now put into a muffle, and the whole is submitted to the heat of a furnace. The flame passes over the cupel, oxidating the lead, which combines with the *base* part of the metal to be assayed, and leaves the pure metal (such as gold or silver) in the shape of a button at the bottom.

Digestion. When a solid substance, in powder or otherwise, is left for a certain time in a fluid, and the mixture is kept exposed to a slow degree of heat, the process is called digestion.

Saturation. When one substance which has an affinity to another, is mixed with as much of that other substance as its affinity will enable it to hold in combination, then the former substance is said to be saturated, or the mixture to have attained the point of saturation. If the mixture contain a greater proportion of either substance, it is said to contain an excess, or to be surcharged. The same thing must be understood of the compounds of more than two substances.

Combustion, is when a body is in the act of burning in any air or gas capable of supporting flame.

Deflagration, is when the combustion is attended with explosions or cracklings.

Detonation, is a pretty loud report.

Operations in the Dry, and Humid Way.—When strong degrees of heat are used, chemical operations are said to be performed in the dry way. The humid way is when fluids are used in the solution of bodies.

All the various parts of this science are found under their respective titles in the work, as Elements of Bodies, Gases, Metals, &c.

CHERT, or Chirk, is the name given by the miners to a siliceous slate, which is massive, not disposed to pass into thin layers, but occurring in thick beds. Colour bluish, passing into yellowish gray. Fracture splintery; edges translucent; specific gravity 2·6363. Blocks of it are used in the porcelain manufactories in the midland counties for grinding flint-stones for the finer porcelain, and the purity of the rock augments the product of fine siliceous earth by its own attrition during the process. There is another sort called by the miners *White Chert*, which seems to be a transition of siliceous slate into quartz. It is not only used for grinding flints, but also as common millstone. A variety of chert has been found to answer as well as the best buhr stones of France in flour-mills, and is manufactured for that purpose. They may be had from 50 lb. to several hundred weight each.

CHESS, a game performed with different pieces of wood, on a board divided into 64 squares or houses, in which chance has so small a share, that it is a matter of doubt whether a person ever lost but by his own fault. Each player has eight dignified pieces; namely, a king, a queen, two bishops, two knights, and two rooks, also eight pawns, all of which are of two different colours, or white and black. *See* Automaton Chess Player.

CHESNUT Tree. Next to the oak, the Spanish chesnut timber is most coveted by carpenters and joiners. It likewise makes the best stakes, pallisadoes, vine-props, hop-poles, &c. and is also proper for mill-timber and waterworks. It is likewise fit for chests, tables, bedsteads, columns, &c. It was anciently very much used in the building of churches in this island, and must have been abundant, though now rare. The horse chesnut-tree is a very perishable wood.

CHILIAD, an assemblage of several things ranged by thousands. The term was particularly applied to tables of logarithms, which were at first divided into thousands.

CHILIÆDRON, a solid figure of 1000 faces.

CHILIAGON, in Geometry, a regular plane figure of 1000 sides and angles.

CHIMES of a Clock, a kind of periodical music produced at equal intervals of time, by means of a particular apparatus added to the clock

CHIMNEY. The rules for building chimneys are: 1. That no timber be laid within twelve inches of the foreside of the chimney jambs. 2. That all the joists on the back be laid with a trimmer. 3. That no timber be laid within the funnel of any chimney.

CHIVALRY, in Antiquity, an institution which, according to some writers, took its rise from the crusades; but, according to others, it gave occasion to that enterprise; and which, though founded in caprice, and productive of extravagance, had a very considerable influence in refining the manners of the European nations, during the twelfth, thirteenth, fourteenth, and fifteenth century. Chivalry was employed in rescuing humble and faithful vassals from the oppression of petty lords; their women from savage lust; and the hoary heads of hermits (a species of Eastern monks, much reverenced in the Holy Land,) from rapine and outrage. In the mean time, the courts of the feudal sovereigns became magnificent and polite; and, as the military constitution still subsisted, military merit was to be upheld: but destitute of its former objects, it naturally softened into fictitious images and courtly exercises of war, in "justs" and "tournaments;" where the honour of the ladies supplied the place of zeal for the holy sepulchre: and thus the courtesy of elegant love, but of a wild and fanatic species, as being ingrafted on spiritual enthusiasm, came to mix itself with the other characters of the knights-errant, adding gentleness to valour.—This singular institution, in which valour, gallantry, and religion, were so strangely blended, was wonderfully adapted to the taste and genius of martial nobles; and its effects were soon visible in their manners. War was carried on with less ferocity, when humanity came to be deemed the ornament of knighthood no less than courage. More gentle and polished manners were introduced, when courtesy was recommended as the most amiable of knightly virtues. Violence and oppression decreased, when it was reckoned meritorious to check and to punish them. A scrupulous adherence to truth, with the most religious attention to fulfil every obligation, were its characteristics.

CHLORATES, combinations of the chloric acid with oxides, alkalies, &c.

CHLORIC Acid, is a combination of chlorine and oxygen, in greater abundance than in the oxide called enchlorine. By its combination with other substances, it forms the salts called chlorates, formerly denominated oxymuriates.

CHLORIDES, compounds of chlorine with various other substances.

CHLORINE, formerly supposed to be a compound of oxygen and the muriatic acid, was called by the French oxymuriatic acid gas, but Sir H. Davy having found it resisted the most powerful means used to decompose it, considered it a simple substance, and this is now the received opinion.

Mix in a mortar three parts of common salt, and one of black oxide of manganese. Introduce them into a glass retort, and add two parts of sulphuric acid. Gas will issue, which must be collected in the water-pneumatic trough. This gas is of a greenish yellow colour, easily recognized by daylight, but scarcely distinguishable by artificial light. Its odour and taste are disagreeable, strong, and so characteristic, that it is impossible to mistake it for any other gas. Its specific gravity is 2·4733. In its perfectly dry state, it has no effect on dry vegetable colours. With the aid of a little moisture, it bleaches them into a yellowish white. Scheele first remarked this property: Berthollet applied it to the art of bleaching in France, and from him Mr. Watt introduced it into Great Britain. If a lighted wax taper be immersed rapidly into this gas, it consumes very fast, with a dull reddish flame, and much smoke. The taper will not burn at the surface of the gas. Its taste is somewhat astringent, but not in the least degree acidulous. When we put in a perfectly dark place, at the ordinary temperature, a mixture of chlorine and hydrogen, it experiences no kind of alteration, even in a great many days. But if, at the same low temperature, we expose the mixture to the diffuse light of day, by degrees the two gases enter into chemical combination, and form muriatic acid gas.

Chlorine and *Hydrogen*, by their union form the muriatic acid, called also the hydrochloric acid. Some substances, when plunged into chlorine in an ignited state, are speedily extinguished, while others, and those the least combustible of all substances, undergo spontaneous combustion. Several of the metals, and gold itself when plunged into it, burst into actual flame, and burn with great brilliancy.

CHLORITES, a kind of green jasper, almost as pellucid as the coarser emeralds. It is sometimes amorphous, and sometimes crystallized. There are four species, *viz.* the earthy chlorite, common chlorite, the foliated, and schistose chlorite.

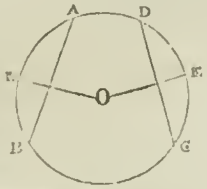
CHOCOLATE, a sort of cake made chiefly from the cocoanut. When the cocoa is properly roasted and cleansed, it is pounded in a mortar, and afterwards ground on a stone. It is then put hot into tin moulds, in which it soon congeals. The Spaniards mix with the cocoa-nuts, cloves, cinnamon, and other ingredients; but in England, the chocolate is made of simple cocoa, with a little sugar and vanilla.

CHOLERA MORBUS, a sudden effusion or overflowing of the bile on the stomach or intestines; and its symptoms are, violent retching, and in some cases, purging.

CHOLOSTERIC Acid, is obtained from cholosterine by heating it with strong nitric acid.

CHOLOSTERINE, the name given to the pearly substance of human biliary calculi.

CHORD, in Geometry, is the right line joining the extremities of any arc of a circle; such are the lines A B, D C.—1. A line drawn from the centre to bisect a chord, is perpendicular to the chord; or if it be perpendicular to the chord, it bisects both the chord and the arc of the chord, as O E, O E. 2. Chords which are equally distant from the centre of a circle, are equal to each other; or if they are equal to each other, they are equally distant from the centre. 3. The chord of an arc is a mean proportional between the diameter and versed sine of that arc.



Line of Chords. *See* Plane Scale and Sector.

Chord, or *Cord*, in Music, denotes the string or line, from the vibration of which the sensation of sound is excited: and by whose divisions the several degrees of time are determined.

CHOROGRAPHY, the act of making a map of a particular country or province.

CHORUS, in Music, is when, at certain periods of a song, the whole company are to join the singer in repeating certain couplets or verses.

CHROMATICS, that part of the science of optics by which the properties of the colours of light, and of natural bodies, are illustrated and explained.

CHROMIC Acid has been obtained from red oxide of lead, ore of Siberia, and from an ore of iron from the department of Var in France. It has the property of colouring its salts, and hence it has been called chromic. If two parts of the red lead ore of Siberia, in fine powder, be boiled with one of an alkali saturated with carbonic acid, in forty parts of water, a carbonate of lead will be precipitated. and the chromate remain dissolved. The solutions are of a lemon colour, and afford crystals of a somewhat deeper hue. Those of chromate of ammonia are in yellow laminæ, having the metallic lustre of gold. The chromate of barytes is very little soluble, and that of lime still less. They are both of a pale yellow, and when heated give out oxygen gas, as do the alkaline chromates.

CHROMIUM, a very rare metal, found either in the form of chromate of lead, or of chromate of iron. The emerald of Peru, and spinel ruby, owe their colours to this metal. Chromium is obtained from its native combinations by decomposing them by the alkaline carbonates, precipitating the chromic acid, and heating it strongly in a crucible. Chromium is a porous mass of agglutinate grains, brittle, of a white between tin and steel. Specific gravity 5·9. It is susceptible of a small degree of magnetism. It resists all the acids, except the nitromuriatic.

CHRONOLOGY, is that science which treats of time, and shews its different measures or computations, as they have been observed by different nations. By chronology we are enabled truly to date the beginning and end of the reigns of princes, the births and deaths of eminent persons, the revolutions of empires and kingdoms, battles, sieges, or any other remarkable events. Without this useful science, that is to say, without distinguishing the times of events as clearly as the nature of the case will admit, history would be little better than a *heap* of confusion, destitute of light, order, or beauty *See* Time, Year, Æras, &c.

CHRONOMETER, in general, means an instrument used in measuring time, as dials, clocks, watches, &c. The term, however, is commonly used for a machine so contrived as to measure a small portion of time with great exactness, even to the sixteenth part of a second, and which is of great use in astronomical observations, ascertaining the time of the fall of bodies, the velocity of running waters, &c. The lamp chronometer consists of a chamber lamp, or a cylindrical vessel about three inches high, and one inch diameter. To the stand is fixed a handle, which supports a frame, covered with oiled paper, about 12 inches high, and 4 wide. This frame is divided into 12 equal parts by horizontal lines, at the ends of which are marked the hours, and between the lines are diagonals divided into halves, quarters, &c. On the handle, and next to the glass, is fixed a stile, and as the distance of this stile from the flame of the lamp is only half an inch, if the distance of the frame from the stile be 6 inches, then while the float containing the light descends by the decrease of the oil, one inch, the shadow of the stile on the frame will ascend 12 inches, and thus shew, by its progression, the increase of the hours with the several divisions. The oil must be very pure, and the wick of the same size and substance.

CHRYSALIS, or Aurelia, in Natural History, denotes the state of seeming insensibility, in which butterflies, moths, and some other insects, pass through before they arrive at their winged or perfect state. The figure of the chrysalis is generally conical; and the creature, when in this state, seems to have neither legs, wings, nor motion. It is almost destitute of life, for it takes no nourishment, nor has it apparently any organs for the purpose. The external covering of the chrysalis is membraneous, smooth, and glossy, but some of them have hairs; and others are rough all over like shagreen. They are divided generally into two classes, the round and the angular, and of these again there are several subordinate distinctions. Some of them are very beautiful. The time of the animal in the chrysalis state varies in different species, some being no more than eight days, while others are as many months.

CHRYSOLITE, in Natural History, a gem to which the ancients gave the name of topaz; their true chrysolite being that which modern jewellers call topaz. The chrysolite is found in angular fragments and crystallized. It is of a green colour, and there are two varieties, 1. the common chrysolite, found in Ceylon, South America, and Bohemia: its colour is a yellowish green. 2. Olive chrysolite, is found commonly in basalt, and is of an olive-green colour.

CHRYSOPRASE, a mineral found in Germany, and which is always amorphous. It is of a green colour, and splintery.—Also, a variety of chalcedony used in jewellery. It consists of 90 silica in the 100.

CHRYSOPRASUS, in Christian Antiquity, the tenth of those precious stones which adorned the foundation of the heavenly Jerusalem: the colour of it was green, inclining to that of gold, as its name imports. See Revelation, chap. xxi. 20.

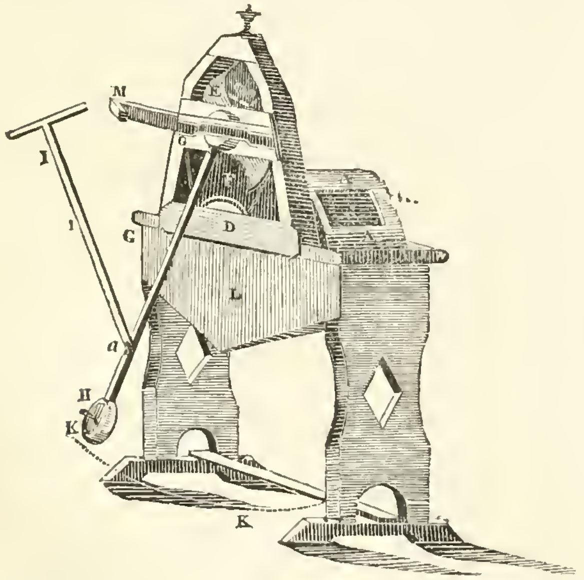
CHURCHWARDENS, the guardians or keepers of the church, are persons annually chosen in Easter week, by the joint consent of the minister and parishioners—or according to the custom of the respective places—to look after the church and churchyard, and things thereunto belonging. They are intrusted with the care and management of the goods and personal property of the church, which they are to order for the best advantage of the parishioners; but they have no interest in, or power over, the freehold of the church itself, or of any land or other real property belonging to it: these are the property of the parson or vicar, who alone is interested in their loss or preservation. The churchwardens, therefore, may purchase goods and other articles for the use of the parish; they may, likewise, with the assent of the parishioners, sell or otherwise dispose of the goods of the church; but without such consent, they are not authorized to alienate any of the property under their care.

All peers of the realm, clergymen, counsellors, attorneys, clerks in court, physicians, surgeons, and apothecaries, are exempt from serving the office of churchwarden, as is every licensed dissenting teacher.

CHURN, an implement for agitating cream or milk, so as to separate the butyrous particles from the serous, and to effect the production of butter.

The inferiority of the churns in common use has induced several ingenious mechanics to exert their skill in contriving others that would render the process of making butter less tedious and expensive. Of these, one of the most valuable is Bowler's improved churn, with which the Society for the Encouragement of Arts, &c. were so well satisfied as to present the inventor with thirty guineas. This churn renders the operation of making butter far less fatiguing; and it has, besides, some peculiar advantages, which will appear in our description.

This churn is of the barrel kind, being a cylinder 18 inches in diameter, and 9 wide; the sides are of wood, and the rim a tin plate, which has two openings, one 8½ inches in length, and 4 in width, through which the cream is poured into the churn, and the hand introduced for cleaning it; the other a short pipe, one inch in diameter, by which the buttermilk runs out of the churn when the operation is finished. The first of these openings has a wooden cover, fastened down by two screws; and the other a cork fitted to it, while the butter is churning. There is further, near the larger opening, a small vent-hole with a peg, to admit the passage of any air that may be discharged from the cream at the beginning of the operation. An axle also through the churn, terminating in two gudgeons, on which it passes, hangs; its lower part being immersed in a trough, in order to hold occasionally either hot or cold water, according to the season of the year. On the inside of the rim are four projecting pieces of wood, with holes, serving to agitate the cream by the motion of the churn. The movement is caused by a pendulum 3 feet 6 inches long, that has an iron bob weighing 10 lbs. and at its upper end a turning pulley 10 inches in diameter, from which a rope goes twice round another pulley about 3 inches in diameter, fixed on the axis of the churn, which it causes to make a partial revolution by each vibration of the pendulum.



There are likewise sliding covers to the machinery, and another to the water trough; in order, when hot water is used, to secure the steam, and keep the cream in a proper degree of warmth. The motion of the pendulum is given, and continued, by means of a wooden rod about 3 feet 9 inches in length, which turns on a pin 3 inches above the bob of the pendulum. If there be a transverse handle at the upper end of this wooden rod, a boy may give motion to the churn with great facility, even while sitting; the action being then much like that of rowing, one of the most advantageous methods of applying human force.

In the figure, A A is the body. B, an opening by which the cream is put in. C, the cover of the large opening: the small hole on the opposite side of the churn cannot be shewn in this view. D, the gudgeon on which the body of the churn hangs. E, the upper or larger pulley. F, the smaller pulley fixed on the axis or gudgeon of the churn. G G, the rod of the pendulum hanging from the upper pulley E. H, the bob of the pendulum. I I, the handle, moveable on a pin at *a*, by which the pendulum is moved to and fro, making a traverse in form of the dotted line K K. L, the trough for the hot or cold water. M, a projecting piece of wood, with a shoulder, by which the handle I is supported, when the churn is not at work.

CHYLE and CHYME. *See* BLOOD. When food has been received into the stomachs of animals, by the action of the saliva and a juice in the stomach called the gastric juice, it is converted into a milky fluid called chyme. This fluid afterwards passes into the intestines, where it unites with the pancreatic juice and bile, and is there separated into chyle, or into feculent matter, which is carried on and discharged. Chyle is taken up by the lacteal absorbent vessels, and finds its way into the blood, which is circulated over the whole system, and supplies its constant waste.

CICATRIX, in Surgery, a little seam or elevation of callous flesh rising on the skin after the healing of a wound or ulcer. It is commonly called a scar.

CICHORIUM, SUCCORY, a genus of the polygamia æqualis order, in the syngenesia class of plants; belonging to the 49th natural order, compositæ. There are three species, 1. Cichorium endivia, the common endive, which is both an annual and biennial plant, and esteemed as a salad. 2. Cichorium intibus, or wild succory, grows naturally by the side of roads, and in shady lanes. It is good in scorbutic complaints. 3. Cichorium spinosum, with a prickly stalk, grows in Sicily, and the islands of the Archipelago.

CIDER, a drink made of the juice of apples. In this process the Devonshire method is preferred, which is, to gather all the apples that have dropped from the trees, from time to time, into a heap, where they are suffered to lie about ten days; secondly, such as are to be gathered from the trees, having acquired some degree of maturity, are laid in a heap by themselves for about a fortnight; and lastly, the hard fruit which are to be left on the trees till frost is apprehended, are laid in separate heaps for a month or six weeks. These heaps are to be made in an open part of the orchard, without any regard to the weather. After having lain the proper time, the apples are ground in a mill resembling that for grinding bark, and the pumice received in a large open vessel, capable of containing as much as is sufficient for one making, or cheese as it is termed. This pumice should remain no longer in the vat than till there is enough broken for one pressing. The stooming or stumming of cider is done by burning a match in a clean hogshead, moist from recent rinsing, and racking the cider on the fret into it. If much on the fret, when the cider is half racked into the scented cask, burn another match in each cask, rolling the same well about for a couple of hours. Stum is the rich must of good cider, blended with the vapour of the burning match, which prevents its fermenting; and when disposed to fret, must be racked into another cask, well matched. Stum is used to mend declining cider, to make it ferment afresh, and give to it new life and sweetness. Boiled cider makes the best stum for keeping.

CIDER *Wine.*—The method of preparing this liquor in America, where it is much used, is as follows: the fresh apple juice is evaporated in a brewing copper till half of it be wasted; the remainder is then put into a wooden cooler, and afterwards into a cask, with an addition of yeast, and so fermented in the ordinary way. This process has lately been adopted in some of our cider counties; but from the impregnation of the copper in the liquor, the public ought to be guarded against the use of it.

CIMEX, or BUG, a genus of hemipterous insects, of which there are above 121 species. The larvæ of bugs only differ from the perfect insect by the want of wings; they run over plants, and change to chrysalies without undergoing any material change. The cimex lectolarius, or house-bug, is acceptable to spiders, and even sought after by the wood-bug. Various methods have been recommended for destroying this pernicious insect, as oil of turpentine, camphor, &c. One of the best methods for extirpating these insects from bedsteads, is by thoroughly washing all the parts where they are likely to lodge, with a solution of corrosive sublimate. Great caution should be had in the use of this mixture, as it is one of the most deadly poisons known.

CIMOLIA Alba, the earth of which tobacco pipes are made. It is dense, compact, heavy, of a dull colour, and of a very close texture. It is found in the Isle of Wight, Dorsetshire, Devonshire, and Staffordshire. Cimolia *Nigra*, is of a dark lead colour, hard, dry, and heavy. It burns perfectly white, and is found in Northamptonshire, where it is used for making pipes.

CINCTURE, or Ceincture, in Architecture, a ring or list at the top and bottom of the shaft of a column.

CINNABAR, in Natural History, is either native or factitious. The *native* is an ore of quicksilver moderately compact, very heavy, and of a striated colour. *Factitious* cinnabar, is a mixture of mercury and sulphur sublimated, and reduced to a fine red substance. The principal use of it is in painting, when it passes under the name of vermilion. In medicine, it is recommended as a sedative and antispasmodic; also as a mercurial fumigation in venereal cases.

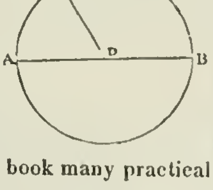
CINNAMON, the bark of two species of laurus. The true sort is from the laurus cinnamomum, and the base kind from the laurus cassia. Cinnamon is an astringent in the *primæ viæ*, but in the remoter seats of action it is an aperient and an alexipharmic. It is useful in diarrhœas and flatulencies. The oil of cinnamon is made now in England, and is much better than what was formerly imported from Holland. Cinnamon water is made by distilling the bark first infused in spirit of wine or brandy.

CINQUE PORTS, five havens that lie on the east part of England, towards France, which have a particular policy, and are governed by a keeper, with the title of the lord warden of the Cinque Ports, which office belongs to the constable of Dover; and their representatives are called Barons of the Cinque Ports. These five ports are, Dover, Hastings, Romney, Hythe, and Sandwich; to which Winchelsea and Rye have been since added.

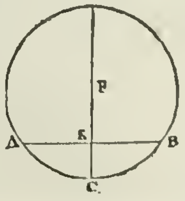
CIPHER, or Cypher, one ot the Arabic characters used in arithmetic. It is also a kind of conjunctive character, consisting of letters interwoven: these are generally the initials of a person's name. Cipher also denotes certain secret characters disguised and varied, used in writing letters for the purpose of secrecy. The properties necessary in this kind of writing are, that the cipher be easy to read by the person for whom it is intended, and clear of suspicion by any stranger into whose hands the same may fall.

CIRCINUS, *the Compasses*, is a small constellation south-east of Centaurus, containing only four stars, and one only of these measures the 4th magnitude.

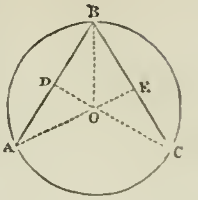
CIRCLE, a plane figure continued by one line, which is calcld the circumference, and is such that all straight lines, drawn from a certain point within the figure, to the circumference, are equal to one another, and this point is called the centre of the circle. The diameter passes through the centre, as A B; and a radius is one-half a diameter, as D C, or D B. The third book of Euclid's Geometry contains the theory of the circle, and the 4th book many practical problems of and belonging to the circle.



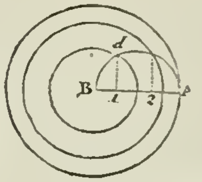
1. To find the centre of a circle. Draw any right line A B within the circle; bisect this line in K, and through the point K draw C D perpendicular, or at right angles, to A B, and bisect C D in E; the point E is the centre of the circle.



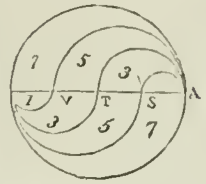
2. To describe a circle through three given points, A, B, C. Join the points A B, B C; bisect A B, B C, in the points D and E by the perpendiculars D O, E O; and the point of intersection O will be the centre, and O A, or O B, or O C, the radius required.



3. To divide a given circle into any number of co-centric parts, equal to each other. Draw the radius A B, and on it describe the semicircle A *e d* B. Divide A B into the proposed number of equal parts 1, 2, &c. and erect the perpendiculars 1 *d*, 2 *e*, &c. meeting the semicircle in *d*, *e*, &c. From the centre B, and radii B *d*, B *e*, &c. describe circles; so shall the circle be divided into the proposed number of equal co-centric parts.



4. To divide a circle into any number of parts, equal both in area and periphery, as in the following figure. Divide the diameter A B into the proposed number of equal parts at the points S, T, V, &c.; then on one side of the diameter describe the semicircles on the diameters A S, A T, A V; and on the other side of the diameters B V, B T, B S; so shall the parts 1 7, 3 5, 5 3, 7 1, be all equal, both in area and periphery.



Quadrature and Rectification of the Circle.—This is a problem, which, of all others, has most engaged the attention of mathematicians, at least amongst the ancients; for being the most regular and best known of any curvilinear figure, it soon became a question to determine its area; and as no reason could be seen why this should not be found, the greater part of the ancients seem to have attempted the solution of it, as have likewise several of the moderns. In the present day, however, though the problem has not been demonstrated to be absolutely impossible, yet few trials are now made, and the solution is given up as hopeless. But though neither the rectification nor quadrature of the circle has been completely determined, yet approximations to them have been found, and some of these to such a degree of accuracy, that in a circle whose diameter is equal to that of the orbit of Saturn, we should not, in assigning its circumference, differ from the truth, in the breadth of a single hair.

We cannot, in the present article, enter into investigations of the several approximating rules that have been given for finding the circumference and area of a circle; and in the present instance, we must content ourselves with merely stating the several results, without entering at all into the methods made use of in determining them.

The simplest and most ancient approximation is as follows: As 7 to 22, so is the diameter to the circumference. This is the ratio given by Archimedes. Other approximations, nearer than the above, but in larger numbers, are as follows: *viz.*

$$\text{as}\quad \left.\begin{array}{r} 106 : 333 \\ 113 : 355 \\ 1702 : 5347 \\ 1815 : 5702 \end{array}\right\}\text{so is diameter to the circumference,}$$

which are each more accurate than the preceding one.

Circle of *Curvature*, in Geometry, that circle, the curvature of which is equal to that of any curve at a certain point. It is also called the circle of equi-curvature.

Circles of the *Sphere*, such as cut the mundane sphere, and have their circumference in its surface. They are either moveable or fixed. The first, are those whose peripheries are in the moveable surface, and which therefore revolve with its diurnal motion; as the meridians, &c. The latter, having their periphery in the immoveable surface, do not revolve; as the ecliptic, equator, and its parallels, &c. The circles of the sphere are either great or little. A great *Circle* of the sphere, is that which divides it into two equal parts or hemispheres, having the same centre and diameter with it; as the horizon, meridian, &c. A little, or less *Circle* of the sphere, divides the sphere into two unequal parts, having neither the same centre nor diameter with the sphere; its diameter being only some chord of the sphere less than its axis, such as the parallels of latitude, &c.

Circles of *Declination*, are great circles intersecting each other in the poles of the world.

Diurnal Circles, are parallels to the equinoctial, supposed to be described by the stars, and other points of the heavens, in their apparent diurnal rotation about the earth. It may here be observed, that most circles of the sphere are transferred from the heavens to the earth; and have thus a place in geography, as well as in astronomy; all the points of each circle being conceived as let fall perpendicularly on the surface of the terrestrial globe, and hence tracing out circles perfectly similar to them. Thus the terrestrial equator is a circle conceived precisely under the equinoctial line, which is in the heavens: and so of the rest.

Circles of *Excursion*, are circles parallel to the ecliptic, and at such a distance from it, as that the excursions of the planets towards the poles of the ecliptic may be included within them; usually fixed at ten degrees.

Circles, *Horary*, in Dialing, are the lines which shew the hours on dials; though these be not drawn circular, but nearly straight. Circle, *horary*, on the Globe, a brazen circle fixed to the north pole, and furnished with an index, shewing the difference of meridians, and serving for the solution of many problems. On globes of late structure, this circle is often placed on the equator, and the index is made to slide on a brass wire running parallel to the equator, and above it.

Circle of *Illumination*, a circle passing through the centre of the earth or moon, perpendicular to a line drawn from the sun to the respective body. This is supposed to separate the illuminated part of the globe from the darkened part; which it does very nearly.

Circles of *Latitude*, or *Secondaries* of the *Ecliptic*, are great circles perpendicular to the plane of the ecliptic, passing through the poles thereof, and through every star and planet. They are so called, because they serve to measure the latitude of the stars, which is nothing but an arch of one of these circles intercepted between the star and the ecliptic.

Circles of *Longitude*, are several less circles, parallel to the ecliptic; still diminishing, in proportion as they recede from it. On the arches of these circles the longitude of the stars is reckoned.

Circle of *perpetual Apparition*, one of the less circles, parallel to the equator; described by any point of the sphere touching the northern point of the horizon; and carried about with the diurnal motion. All the stars included within this circle never set, but are ever visible above the horizon.

Circle of *perpetual Occultation*, is another circle at a like distance from the equator; and contains all those stars which never appear in our hemisphere. The stars situated between these circles alternately rise and set at certain times.

Polar Circles, are immoveable circles, parallel to the equator, and at a distance from the poles equal to the greatest declination of the ecliptic.

Circles, *Druidical*, a name given to certain ancient enclosures, formed by rude stones circularly arranged. These, it is supposed, were temples, or places for solemn assemblies, for councils, or seats of judgment.

CIRCUIT, in Law, a longer course of proceedings than is needful to recover the thing sought for. Circuit also signifies the journey or progress, which the judges take twice every year, through the several counties of England and Wales, to hold courts and administer justice, where recourse cannot be had to the King's courts at Westminster; hence England is divided into six circuits, *viz*. the Home circuit, Norfolk circuit, Midland circuit, Oxford circuit, Western circuit, and Northern circuit. In Wales, there are but two circuits, North and South Wales. Two judges are assigned by the king's commission to every circuit. In Scotland there are three circuits, *viz*. the Southern, Western, and Northern, which are likewise made twice every year, *viz*. in spring and autumn.

CIRCULAR, any thing relating to the circle; as Circular *Arcs*, *Instruments*, *Lines*, *Parts*, *Ring*, &c.

Circular *Ring*, is the measure or space included between two concentric circles, and the area of it is consequently equal to the difference of the areas of the two circles. Or the area may be found thus: Multiply the sum of the two diameters by the difference of them, and that product again by ·7854, which will give the area required.

Circular *Sailing*, the method of moving a ship upon a great circle of the globe.

Circular *Numbers*, a name sometimes applied to numbers whose powers terminate in the same digits as their roots; an old and useless distinction.

Circular *Parts* (Napier's), are five parts of a right-angled, or a quadrantal spherical triangle; they are the legs, the complement of the hypothenuse, and the complements of the two oblique angles.

Circular *Instruments*, or *Reflecting* or *Multiplying Circles*, are instruments which possess all the advantages of accuracy attending large instruments, in diminishing the errors of division and eccentricity at pleasure, by means of reflection, though the instruments themselves are small and portable. Circular instruments may be considered as improvements of Hadley's octant, and the marine sextant, which are for the same purpose; *viz*. for observing the altitudes, distances, &c. of the heavenly bodies, extremely useful for navigators in finding the moon's distance, and other nautical purposes.

CIRCULATING Decimals, or *Recurring Decimals*, are those that consist of a repetition of a small number of digits, as ·646464, &c. ·4127127127, &c.; in fact, every decimal that is not finite, is a circulating decimal, or is such, that if continued far enough the same figures will again recur; but it is only those, of which the periods of circulation consist of a few figures, that receive generally the definition of circulating decimals.

When the circulation consists of the same digit repeated, it is called a *Simple Circulate*, and is distinguished by a point placed over it: thus ·111, &c. $= \cdot\dot{1}$; $\cdot333 = \cdot\dot{3}$, &c. When the period of circulation consists of more than one digit, it is called a *Compound Circulate*, and is distinguished thus, $\cdot234234234$, &c. $= \cdot\dot{2}3\dot{4}$. A *Mixed Circulate* is that which has other figures in it that are not repeated, as ·7848484, &c.; and these are represented thus, $\cdot7\dot{8}\dot{4}$.

All operations, as multiplication, division, &c. of these numbers, may be performed by the same rules as common decimals; and in fact, there are very few cases in which those rules are not to be preferred, though some authors, as Brown, Cunn, Malcolm, Emerson, Donn, and particularly Henry Clarke, have treated at considerable length the theory of circulating decimals; as also Dr. Wallis, who seems to have been the first author that distinguished them under a separate head.

Reduction of Circulating Decimals.—Case 1. To reduce a Simple or Compound Circulate to its equivalent Fraction.—*Rule*. Take the figures in the given decimal, considered as a whole number, for the numerator; and as many 9's as there are places in the circulate for the denominator; observing only, that when there are any integral figures in the circulate, as many ciphers must be annexed to the numerator, as the highest place in the repetend is distant from the decimal point thus,

Examples. ...... 1. The circulate $\cdot\dot{6} = \frac{6}{9} = \frac{2}{3}$

2. .... $\cdot\dot{3}\dot{6} = \frac{36}{99} = \frac{4}{11}$

3. .... $\cdot\dot{0}\dot{9} = \frac{9}{99} = \frac{1}{11}$

4. .... $2\cdot\dot{0}6\dot{3} = 2\frac{63}{999} = 2\frac{7}{111}$

Case 2. To reduce a Mixed Circulate to its equivalent Fraction.—*Rule*. Subtract the finite part of the expression, considered as a whole number, from the whole mixed repetend, taken in the same manner for the numerator: and to as many 9's as there are repeating places in the circulate, annex as many ciphers as there are finite decimal places for a denominator; thus,

Examples.—1. The circulate $13\dot{8} = \dfrac{138 - 13}{900} = \frac{125}{900} = \frac{5}{36}$

2. Again .... $2\cdot4\dot{1}\dot{8} = 2\dfrac{418 - 24}{990} = 2\frac{414}{990} = 2\frac{23}{55}$

And so on in other examples. Having thus shewn how to reduce any circulate, simple, compound, or mixed, to its equivalent fraction; all the rules of addition, subtraction, multiplication, division, &c. of circulating decimals, may be performed by the rules that are given for the same operations in fractions; which see under their respective heads.

CIRCULATION of the Blood, the natural motion of the blood in a living animal, whereby that fluid is alternately carried from the heart to all parts of the body by the arteries, and returned from the same parts to the heart by the veins.

CIRCULUS, a chemical instrument, consisting of an iron ring, which being heated red-hot, is applied to the necks of glass vessels to make the necks come evenly off.

CIRCUMFERENCE, Circumferentia, in a general sense, denotes the line or lines bounding any figure; but it is commonly used, in a more limited sense, to denote the periphery of a circle, which is every where equally distant from a certain point within, called the centre. *See* Circle.

CIRCUMFERENTOR, an instrument used by surveyors in taking angles; it consists of a brass circle and index, in one piece, commonly about seven inches in diameter, an index about fourteen inches long, and one and a half inches broad. On the circle is a card or compass, divided into 360 degrees; the meridian line of which answers to the middle of the breadth of the index. There is also soldered on the circumference a brass ring, on which screws another ring with a flat glass in it, so as to form a kind of box for the needle, suspended on the needle in the centre of the circle. There are also two sights to screw on, and slide up and down the index, as also a ball and socket screwed on the under side of the circle, to receive the leg of the three-legged staff.

The above description answers to the most simple form of the circumferentor; but an improved instrument of this kind is sold by Jones, of Holborn, which in some measure answers the purpose of a theodolite.

CIRCUMGYRATION, the whirling motion of a body about a centre.

CIRCUM-Polar *Stars*, are those situated near the north pole of the heavens, or those which revolve about it without setting.

CIRCUMSCRIBED Figure, is that which is circumscribed or drawn about another figure, so as to touch it on every side.

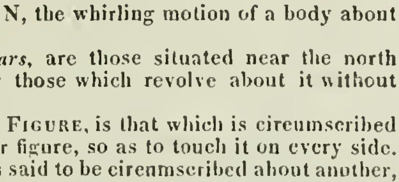
A right-lined figure is said to be circumscribed about another, when all the angles of the latter fall in the sides of the former. A right-lined figure circumscribes a curvilinear one, when the periphery of the latter touches all the sides of the former. A circle, or other curvilinear figure, circumscribes a right-lined one, when all the angles of the latter are in the periphery of the former.

Circumscribed *Hyperbola*, one of Newton's hyperbolas, of the second order, which cuts its asymptotes, and contains the part cut off within itself.

CIRCUMVALLATION, in military affairs, is a fortification of earth, consisting of a parapet and trench made round a town intended to be besieged, when opposed to any army that may come to its relief.

CIRRI, in botanical language, denotes the fine strings or filaments by which creeping plants adhere to walls and trees. In ichthyology, the term is applied to appendages hanging from the mouths of fishes, and called by some, beards.

CISSOID of Diocles, in the higher Geometry, is a curve line of the second order, invented by Diocles, an ancient Greek geometrician, for the purpose of finding two continued mean proportionals between two other given lines. The generation of this curve is as follows: At the extremity B of the diameter A B of the circle A O B, draw perpendicular to it the indefinite line C B D, to which from the other extremity A draw several lines cutting the circle in I, O, N, &c. and upon these lines set off the corresponding equal distances, *viz.* H M = A I, FO = A O, C L = A N, &c.; then the curve line drawn through all the points M, O, L, &c. is the cissoid. Other methods of constructing this curve may be seen in Newton's "Universal Arithmetic," and Emerson on "Curve Lines."



CISTERN, on board of ships, is a large wooden trough, placed in the well just below the orlop, and having a leaden pipe, which goes through the ship's side, whereby it is occasionally filled with sea water, which is thence pumped up to wash the decks, &c.

CISTUS, the *Rock Rose*, a genus of the monogynia order, in the polyandria class of plants, ranking in the natural method under the 20th order, rotaceæ. There are 66 species, mostly natives of the southern parts of Europe. They are very beautiful evergreen shrubs, and very ornamental in gardens. The flowers are white, purple, and yellow; they are propagated by seeds or cuttings. Gum labdanum is obtained from the species in the Levant.

CITADEL, a place fortified with four, five, or six bastions, on a convenient hill, near a city which it commands.

CITATION, in ecclesiastical courts, is the same with a summons in the civil.

CITRUS, the citron, orange, and lemon tree, a genus of the polyadelphia class, and icosandria order of plants. Calyx quinquefid; petals oblong, and five; antheræ twenty, filaments unite into various bodies; fruit nine-celled. There are five species, and many varieties. 1. Citrus aurantium, the orange, of which the varieties are, the Seville orange, a handsome tree, and the hardiest of any. The fruit is large, rough-rinded, and sour. 2. The China orange, which has a smooth, thin rind, and sweet fruit. 3. The forbidden fruit-tree, very much resembles the common orange-tree, but the fruit is large; the flavour is delicious. 4. The horned orange, is a tree of moderate size, producing fruit which divide, and the rind has divisions like horns. 5. The hermaphrodite orange produces fruit formed partly like that of the orange, and partly like a citron. 6. The dwarf orange tree, or nutmeg orange, grows to the height of two or three feet, and the fruit is very small. II. Citrus medica, the citron tree, of which there are six varieties. The lemon tree is accounted a variety of the citron, and of this there are not less than eleven sorts. Besides these varieties of the citrus there are several others, as, 1. The citrus trifoliata, a thorny shrub, which grows in Japan. 2. Citrus decumana, or shaddock, which is a native of the East and West Indies. 3. Citrus Japonica, the fruit of which is about the size of a cherry, and very pleasant to the taste.

CIVET, is collected betwixt the anus and the organs of generation of a fierce carnivorous quadruped, met with in China, and the East and West Indies, called a civet cat; but bearing a greater resemblance to a fox or marten than a cat: it is a species of Viverra. Several of these animals have been brought into Holland, and afford a considerable branch of commerce, particularly at Amsterdam. The civet is squeezed out in summer every other day; in winter twice a week: the quantity procured at once, is from two scruples to a drachm, or more. The juice thus collected is much purer and finer than that which the animal sheds against shrubs or stones in its native climates. Good civet is of a clear yellowish or brownish colour, not fluid, nor hard, but about the consistence of butter or honey, and uniform throughout; of a very strong smell; quite offensive, when undiluted; but agreeable, when only a small portion is mixed with other substances.

CIVIL Day, like the astronomical or natural, consists of twenty-four hours, but begins differently in different nations. The ancient Babylonians, Persians, Syrians, and most of the eastern nations, began their day at sun-rising. The ancient Athenians, the Jews, &c. began their day at sun-setting, which custom is followed by the modern Austrians, Bohemians, Silesians, Italians, Chinese, &c. The Arabians begin their day at noon, like the modern astronomers. The ancient Egyptians, Romans, &c. began their day at midnight, and this method is followed by the English, French, Germans, Dutch, Spanish, and Portuguese.

CIVILIAN, a term applied to the doctors and professors of the civil law. In London they have a college, called Doctors' Commons.

CIVIL LAW, is properly the peculiar law of a state, country, or city, but is now applied exclusively to a body of laws compiled out of the best Roman and Grecian systems of jurisprudence, agreeable to what is denominated the law of nature and nations, and which were generally observed throughout the Roman dominions above 1200 years. In our country, the civil law is used in the ecclesiastical courts and the admiralty, but is subservient to the common law.

CIVIL Year. *See* Year.

CLAMPS, in Naval Architecture, thick planks on the inner part of a ship's side, used to sustain the ends of the beams, and extending from stem to stern, including the whole interior range of the side. They are placed close under each deck, so as to be securely fayed to all the timbers, to which they are fastened by nails through the clamp, and penetrating two-thirds of the thickness of the timbers.

The clamps of the lower and second decks ought to be equal in thickness to half the corresponding timbers in that part, and as broad as can be procured. In their disposition it is essentially necessary to avoid their being wounded by the ports, as the strength and firmness of a ship greatly depend on the substance and solidity of those pieces which lie horizontally in her frame.

Clamps are also smooth crooked plates of iron fore-locked upon the trunnions of the cannon, to keep them fast upon their carriages: these, however, are more properly termed cap-squares. Clamps of the latter kind are likewise frequently used to fasten the masts or bowsprits of small vessels, and of boats.

CLAN, a term used in Scotland to denote a number of families of the same name, under a feudal chief, who protected them, and in return for that protection commanded their services as his followers, and led them to war, and on military excursions.

CLARENCIEUX, the second king at arms, so called from Lionel Duke of Clarence, to whom the title originally appertained. His office is to marshal the order of procession in the funerals of the inferior nobility, &c.

CLARIFICATION, in Chemistry, the clearing and fining any fluid from heterogeneous matter.

CLARO OBSCURO, in Painting, the art of distributing advantageously the light and shadow of a piece with regard to the ease of the eye, and the effect of the whole. It also denotes a design consisting of only two colours, usually black and white, or black and yellow.

CLASS, a term given to the general divisions of a subject: thus in the Linnæan system, animals and plants are divided into classes.

CLAY, a kind of earth, which was formerly denominated argillaceous, but is now found to be a mixture of alumina and silica in various proportions. Clay also contains carbonate of lime, of magnesia, barytes, oxide of iron, &c. It adheres slightly to the tongue; feels greasy; and falls to powder in water. When pure, it is white with a tinge of blue or yellow. Potters' clay stains the fingers, and acquires a polish by rubbing. When properly moistened, it is very ductile. Tobacco pipe clay is a variety of this species. The structure of schistose clay is slaty, and of a gray colour. It is usually found in coal mines.

CLAY SLATE, is a mineral extensively distributed, forming part of primitive and transitive mountains. Its constituents are 48·6 silica, 23·5 alumina, 1·6 magnesia, 11·3 peroxide of iron, 0·5 oxide of manganese, 4·7 potash, 6·3 carbon, 0·1 sulphur, and 7·6 water and volatile matter.

CLEATS, pieces of wood of different shapes, used occasionally in a ship, to fasten ropes upon: some have one, and some two arms; others are without arms, being hollowed in the middle to tie any thing to, and are called belaying cleats, a deck cleat, and a thumb cleat.

CLEF, or Cliff, in Music, a mark set at the beginning of a song, denoting the key in which the same is to be performed, or it is a letter marked on a line, to explain the rest.

CLEOSTRATUS, a celebrated astronomer, born in Tenedos, was, according to Pliny, the first who proposed the signs of the zodiac; others say, that he only invented the signs Aries and Sagittarius. He also corrected the errors of the Grecian year, about the 306th before Christ.

CLEPSYDRA, an instrument or machine serving to measure time by the fall of a certain quantity of water, though there have likewise been clepsydræ made with mercury. The Egyptians, by this machine, measured the course of the sun. Tycho Brahe, in later days, made use of it to measure the motion of the stars, &c.; and Dudley used the same contrivance in making all his maritime observations. The use of clepsydræ is very ancient; they were invented in Egypt, under the Ptolemies; as were also sun-dials. Their use was chiefly in the winter, as the sun-dials served in the summer: but they had two great defects; the one, that the water ran out with a greater or less facility, as the air was more or less dense; the other, that the water ran more readily at the beginning than towards the conclusion.

The Construction of a common Clepsydra.—To divide any cylindrical vessel into parts, to be emptied in each division of time; the time wherein the whole, and that wherein any part is to be evacuated, being given: Suppose a cylindrical vessel, whose charge of water flows out in twelve hours, were required to be divided into two parts, to be evacuated each hour. 1. As the part of time 1 is to the whole time 12, so is the same time 12 to a fourth proportional 144. 2. Divide the altitude of the vessel into 144 equal parts: here the last will fall to the last hour; the three next above to the last part but one; the five next to the tenth hour; lastly, the twenty-three last to the first hour. For since the times increase in the series of the natural numbers 1, 2, 3, 4, 5, &c. and the altitudes, if the numeration be in a retrograde order from the twelfth hour, increase in the series of the unequal numbers 1, 3, 5, 7, 9, &c. the altitudes computed from the twelfth hour will be as the squares of the times 1, 4, 9, 16, 25, &c. Therefore the squares of the whole time, 144, comprehend all the parts of the altitude of the vessel to be evacuated. But a third proportional to 1 and 12 is the square of 12, and consequently it is the number of equal parts in which the altitude is to be divided, to be distributed according to the series of the unequal numbers, through the equal interval of hours. There were many kinds of clepsydræ among the ancients; but they had all this in common, that the water ran generally through a narrow passage, from one vessel to another, and in the lower was a piece of cork or light wood, which, as the vessel filled, rose up by degrees, and shewed the hour.

Clepsydræ have been much improved of late years in their construction; but as their use is now superseded by the accuracy of our modern timepieces, we shall not dwell longer upon them here.

CLERK, a word originally applied to a clergyman, from the Greek *κληρος*, *chosen*, whence it was afterwards used to denote a man of learning. In our law, it is still the designation of every person in holy orders under the episcopal dignity. The word *clerk* is now variously applied to persons in numerous offices in the law and the government, as well as to those employed in keeping merchants' books.

CLICKS are small pieces of iron falling into a notched wheel attached to the winchers in cutters, &c. and thereby serving the office of pauls.

CLIMATE, or Clime, in the ancient Geography, a part of the surface of the earth, or zone, bounded by two lesser circles parallel to the equator; and of such a breadth, as that the longest day in the parallel nearer the pole exceeds the longest day in that next the equator, by some certain space, as half an hour or an hour.. Vulgarly, the term *climate* is bestowed on any country or region differing from another, either in respect of the seasons, the quality of the soil, or even the manners of the inhabitants, without any regard to the length of the longest day.

CLINCH, a particular method of fastening large ropes by a kind of knot and seizings, instead of splicing; and is chiefly used to fasten the cable to the ring of the anchor, and the breechings of guns to the ring-bolts in the ship's side.

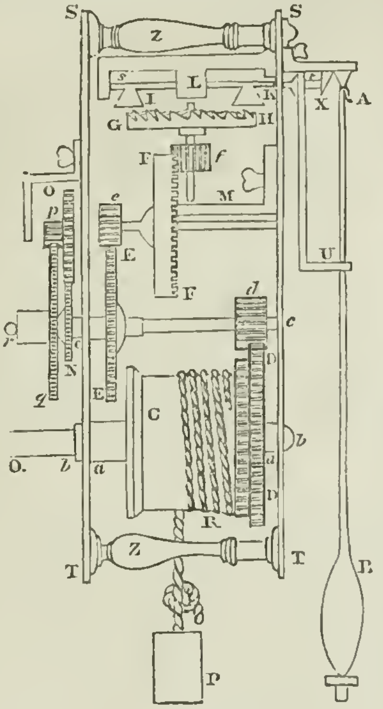
CLINCHER-WORK, the disposition of the planks in the side of any boat or vessel, when the lower edge of every plank overlays that next below it, like slates on the roof of a house.

Clincher-built, made of clincher-work.

CLINCHING, in sea language, is the driving a little oakum into the seams to keep out the water.

CLINICAL, in Medicine, is applied to the practice of visiting and treating patients.

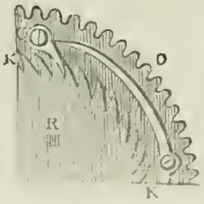
CLOCK, a machine now constructed in such a manner, and so regulated by the uniform motion of a pendulum, as to measure time, and all its subdivisions, with great exactness. Before the invention of the pendulum, a balance, not unlike the fly of a kitchen jack, was used instead of it. Clocks were at first called nocturnal dials, to distinguish them from sun-dials, which shewed the hour by the shadow of the sun. The invention of clocks with wheels is ascribed to Pacificus, archdeacon of Verona, in the 9th century, on the credit of an epitaph quoted by Ughelli, and borrowed by him from Panvinius. Others attribute the invention to Boethius, about the year 510; and some to Archimedes. But we know for certain, that Edward III. gave permission to three artists to come over from Holland to England, and practise their calling here. A modern clock, as in the figure, consists of a variety of parts, which may be thus explained: P is a weight which is suspended by a cord that winds about the cylinder or barrel C, which is fixed upon the axis *a*, *a*; the pivots *b*, *b*, go into holes made in the plates T S, T S, in which they turn freely. These plates are made of brass or iron, and are connected by means of four pillars, Z, Z; the whole together being called the *frame*. The weight P, if not restrained, would necessarily turn the barrel C, with an uniformly accelerated motion, in the same manner as if the weight were falling freely. But the barrel is furnished with a ratchet-wheel, K,K, the right side of whose teeth strikes against the click, which is fixed with a screw to the wheel D D, as represented in the second figure; so that the action of the weight is communicated to the wheel D D, the teeth of which act upon the teeth of the small wheel *d*, which turns upon the pivots *c*, *c*. The communication or action of one wheel with another, is called the *pitching*; a small wheel like *d* is called a *pinion*, and its teeth are called *leaves* of the pinion. Several things are requisite to form a good pitching, the advantages of which are obvious in all machinery where teeth and pinions are employed. The teeth and pinion-leaves should be of a proper shape, and perfectly equal among themselves: the size also of the pinion should be of a just proportion to the wheel acting into it.



The wheel E E is fixed upon the axis of the pinion *d*; and the motion communicated to the wheel D D by the weight is transmitted to the pinion *d*, consequently to the wheel E E, as likewise to the pinion *e* and wheel F F, which moves the pinion *f*, upon the axis of which the crown or balance-wheel G H is fixed. The pivots of the pinion *f* play in holes of the plates L M, which are fixed horizontally to the plates T S. In a word, the motion begun by the weight is transmitted from the wheel G H to the palettes I K, and by means of the fork U X riveted on the palettes, communicates motion to the pendulum A B, which is suspended upon the hook A. The pendulum A B describes, round the point A, an arc of a circle alternately going and returning. If, then, the pendulum be once put in motion by a push of the hand, the weight of the pendulum at B will make it return upon itself, and it will continue to go alternately backward and forward till the resistance of the air upon the pendulum, and the friction at the point of suspension at A, destroys the original impressed force. But as at every vibration of the pendulum the teeth of the balance-wheel G H act so upon the palettes I K (the pivots upon the axis of these palettes play in two holes of the potence *s t*,) that after one tooth H has communicated motion to the palette K, that tooth escapes; then the opposite tooth G acts upon the palette I, and escapes in the same manner; and thus each tooth of the wheel escapes the palettes I K, after having communicated their motion to the palettes in such a manner that the pendulum, instead of being stopped, continues to move. The wheel E E revolves in an hour; the pivot *e* of this wheel passes through the plate, and is continued to *r*; upon the pivot is a wheel N N, with a long socket fastened in the centre; upon the extremity of this socket *r*, the minute-hand is fixed. The wheel N N acts upon the wheel O; the pinion of which *p* acts upon the wheel *g g*, fixed upon a socket which turns along with the wheel N. This wheel *g g* makes its revolution in 12 hours, upon the socket of which the hour-hand is fixed.

From the above description it is easy to see, 1. That the weight P turns all the wheels, and at the same time continues the motion of the pendulum. 2. That the quickness of the motion of the wheels is determined by that of the pendulum. 3. That the wheels point out the parts of time divided by the uniform motion of the pendulum.

When the cord upon which the weight is suspended is entirely run down from off the barrel, it is wound up again by means of a key, which goes on at the square end of the arbor at Q, by turning it in a contrary direction from that in which the weight descends. For this purpose the inclined side of the teeth of the wheel K (as in the annexed figure) removes the click C, so that the ratchet-wheel R turns while the wheel D is at rest; but as soon as the cord is wound up, the click falls in between the teeth of the wheel D, and the right side of the teeth again act upon the end of the click, which obliges the wheel D to turn along with the barrel; and the spring A keeps the click between the teeth of the ratchet-wheel R.



We shall now explain how time is measured by the motion of the pendulum; and how the wheel E, upon the axis of which the minute-hand is fixed, makes but one precise revolution in an hour. The vibrations of a pendulum are performed in a shorter or longer time in proportion to the length of the pendulum itself. A pendulum of $39\frac{1}{8}$ inches in length makes 3600 vibrations in an hour; *i. e.* each vibration is performed in a second of time, and for that reason it is called a *second pendulum*. But a pendulum of $9\frac{25}{32}$ inches makes 7200 vibrations in an hour, or two vibrations in a second of time, and is called *a half-second pendulum*. Hence, in constructing a wheel whose revolution must be performed in a given time, the time of the vibrations of the pendulum which regulates its motion must be considered. Supposing, then, that the pendulum A B makes 7200 vibrations in an hour, let us consider how the wheel E shall take up an hour in making one revolution. This entirely depends on the number of teeth in the wheels and pinions. If the balance-wheel consists of 30 teeth, it will turn once in the time that the pendulum makes 60 vibrations; for at every turn of the wheel the same tooth acts once on the palette I, and once on the palette K, which occasions two separate vibrations in the pendulum; and the wheel having 30 teeth, it occasions twice 30, or 60 vibrations. Consequently this wheel must perform 120 revolutions in an hour; because 60 vibrations, which it occasions at every revolution, are contained 120 times in 7200, the number of vibrations performed by the pendulum in an hour. Now, in order to determine the number of teeth for the wheels E F, and their pinions *e f*, it must be remarked, that one revolution of the wheel E must turn the pinion *e* as many times as the number of teeth in the pinion is contained in the number of teeth in the wheel. Thus, if the wheel E contains 72 teeth, and the pinion *e* 6, the pinion will make 12 revolutions in the time that the wheel makes 1; for each tooth of the wheel drives forward a tooth of the pinion, and when the 6 teeth of the pinion are moved, a complete revolution is performed; but the wheel E has by that time only advanced 6 teeth, and has still 66 to advance before its revolution be completed, which will occasion 11 more revolutions of the pinion. For the same reason, the wheel F having 60 teeth, and the pinion *f* 6, the pinion will make 10 revolutions while the wheel performs 1. Now the wheel F being turned by the pinion *e*, makes 12 revolutions for one of the wheel E; and the pinion *f* makes 10 revolutions for one of the wheel F; consequently the pinion *f* performs 10 times 12, or 120 revolutions, in the time the wheel E performs one. But the wheel G, which is turned by the pinion *f*, occasions 60 vibrations in the pendulum each time it turns round; consequently the wheel G occasions 60 times 120, or 7200, vibrations of the pendulum while the wheel E performs one revolution; but 7200 is the number of vibrations made by the pendulum in an hour, and consequently the wheel E performs but one revolution in an hour; and so of the rest.

From this reasoning, it is easy to discover how a clock may be made to go for any length of time without being wound up. 1. By increasing the number of the teeth in the wheels. 2. By diminishing the number of teeth in the pinions. 3. By increasing the length of the cord that suspends the weight. 4. By increasing the length of the pendulum. And, 5. By adding to the number of wheels and pinions. But in proportion as the time is augmented, if the weight continues the same, the force which it communicates to the last wheel GH will be diminished.

It only remains to take notice of the number of teeth in the wheels which turn the hour and minute hands. The wheel E performs one revolution in an hour; the wheel N N, which is turned by the axis of the wheel E, must likewise make only one revolution in the same time; and the minute-hand is fixed to the socket of this wheel. The wheel N has 30 teeth, and acts upon the wheel O, which has likewise 30 teeth, and the same diameter; consequently the wheel O takes an hour to a revolution: now the wheel O carries the pinion *p*, which has 6 teeth, and which acts upon the wheel *q q* of 72 teeth; consequently the pinion *p* makes 12 revolutions while the wheel *q q* makes one, and of course the wheel *q q* takes 12 hours to one revolution; and upon the socket of this wheel the hour-hand is fixed. Much that has been said here concerning revolutions of wheels, &c. is equally applicable to watches as to clocks.

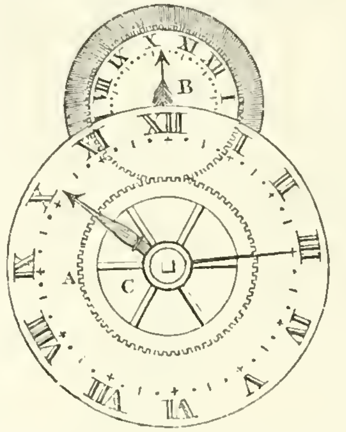
But to speak of the striking part, in which, indeed, as well as the other part of a clock, there is room for a great variety and choice in the construction; the wheels composing this part are, the great or first wheel, moved by the weight or spring at the barrel, in sixteen or thirty hour clocks; this has usually pins, and is called the *pin-wheel*: in eight-day pieces the second wheel is commonly the pin-wheel or striking-wheel, which is moved by the former. Next to the striking-wheel is the detent-wheel, or hoop-wheel, having a hoop almost round it, wherein is a vacancy at which the clock locks. The next is the third or fourth wheel, according to its distance from the rest, called the *warning-wheel*. The last is the flying pinion, with a fly or fan, to gather air, and so bridle the rapidity of the clock's motion. To these must be added the pinion of report, which drives round the locking-wheel, called also the *count-wheel*, ordinarily with eleven notches in it, unequally distant, to make the clock strike the hours. Besides the wheels, to the clock part belongs the rash or ratch; a kind of wheel with twelve large fangs, running concentrical to the dial-wheel, and serving to lift up the detents every hour, and make the clock strike: the detents or stops, which being lifted up and let fall, lock and unlock the clock in striking; the hammer, which strikes the bell; the hammer tails, by which the striking pins draw back the hammers; latches, whereby the work is lifted up and unlocked; and lifting-pieces, which lift up and unlock the detents.—For the other parts of a clock, *see* BALANCE, PENDULUM, and SCAPEMENT.

J. H. G. Dyar, of Vermont, in America, has invented a clock, the principles and movements of which entirely differ from those at present in use. The pendulum moves in a cycloidal arch, and performs long and short vibrations in equal times; while the pendulum of the common clock swings in the arc of a circle, making unequal vibrations in unequal times. In other respects its construction is peculiar; the hammer, which is balanced and turns on a pivot, strikes the internal limb of the bell; and the machinery of the whole is surprisingly simple, but two wheels being required to continue the operation of eight days, without renewing the power: three wheels, it is said, will do this for a year; and four, we are told, will perpetuate the motion for a century. They may be seen at some of the clockmakers in London.

Prior's contrivance for the striking part of a eight day clock, consists of a wheel, on the face of which are cut six turns of a spiral line for counting the hours; the pins below this spiral elevate the hammer, and those above are for the use of the detent. This single wheel serves the purpose of count-wheel, pin-wheel, detent-wheel, and the fly-wheel, and has six revolutions in striking the 12 hours. The flies of clocks turn round, at a mean, above sixty times for every knock of the hammer, but this turns round only three times for the same purpose; and suppose the pivots were of equal diameters, the influence of oil on them would be as the number of revolutions in each.

In some parts of the kingdom, Glasgow to wit, the dials of public clocks have been illuminated by gas; and certainly nothing is more necessary than this addition to our night watch. A dial-plate might be made to revolve on the axis of the fixed dial. The figures shewing the hours being cut in contrary succession, and the span illuminated by a strong gas light.

One on the following plan might be adopted, exactly as it has been suggested by the editor of the "*Register of the Arts and Sciences.*" A is the dial-plate of a common clock, with the hours, &c. marked upon it, as usual; B is the proposed addition to it, for the purpose of exhibiting the time distinctly during the night; C is a light cog-wheel, placed immediately behind the day dial, having its centre fitted in the arbor of the hour-hand, and revolving with it. The night dial B we propose to be made of a plate of glass, with the hours painted upon it in black, and to revolve on an axis in its centre. The index, represented by an arrow, is fixed. The periphery of the glass plate is encompassed by a rim of brass, having cogs in its outer edge, which fit into the cogs of the wheel C; consequently they move together; and being of equal diameters, they perform their revolutions in equal time. The time represented in our engraving is a quarter past ten; when the hour-hand has moved on to XI, (for instance,) the transparent dial B will have moved an equal space past the fixed index, and denote the same precise time. Both dials must, by this simple contrivance, invariably agree in their respective indications of the time. During the day the time is observed on the large dial, as usual; and at night a lighted lamp placed behind the transparent dial will always exhibit the time as distinctly.



CLOSE-HAULED, the arrangement or trim of a ship's sails when she endeavours to make a progress in the nearest direction possible towards that point of the compass from which the wind blows; in this manner of sailing, the keel of square-rigged vessels commonly makes an angle of six points with the line of the wind, but cutters, luggers, and other fore-and-aft rigged vessels, will sail much nearer. All vessels, indeed, are supposed to make nearly a point of lee-way when close-hauled, even when they have the advantage of a good sailing breeze and smooth water. The angle of the lee-way, however, enlarges in proportion to the increase of the wind and sea. In this disposition of the sails they are all extended sideways on the ship, so that the wind, as it crosses the ship obliquely towards the stern from forwards, may fill their cavities. But as the current of wind also unites the cavities of the sails in an oblique direction, the effort of it, to make the ship advance, is considerably diminished: she will, therefore, make the least progress when sailing in this manner. The ship is said to be close-hauled, because at this time her tacks, or lower corners of the principal sails, are drawn close down to her side to windward; the sheets hauled close aft; and all the bowlines drawn to their greatest extension, in order to keep the sails ready.

CLOSE QUARTERS, certain strong barriers of wood stretching across a merchant ship, in several places; they are used as a place of retreat when a ship is boarded by her adversary, and are therefore fitted with loop-holes through which to fire the small arms; they are likewise furnished with caissons, or powder-chests, fixed upon the deck, which may be fired at any time from the close quarters upon the boarders. An English merchant ship of 16 guns, by being properly fitted with close quarters, has been known to defeat the united efforts of three French privateers who boarded her, after having engaged at some distance nearly a day and a half, with very few intervals of rest. Two of the cruisers were equipped with 12 guns each, and the other with 8. The French sailors were, after boarding, so much exposed to the continued fire of musketry, and cohorns charged with grenadoes, that a dreadful scene of carnage ensued, in which the decks were soon covered with the dead bodies of the enemy, several of which the boarders, in their hurry to escape, had left behind.

CLOUD, a visible aggregate of minute drops of water suspended in the atmosphere. The same aggregate, which in this situation is called a cloud, obtains the name of mist, when seen to arise from the earth or waters; and fog, when it envelopes and covers the observer. Yet the two latter, viewed from a greater distance or elevation, present all the appearances of clouds; while those, in their turn, become mists and fogs, in proportion as we approach and penetrate them. It is concluded, from numerous observations, that the particles of which a cloud consists, are always more or less electrified; and this fluid has hence been considered as the cause of the formation of all clouds whatever, whether of thunder, hail, rain, or snow. *See* METEOR.

The hypothesis which assumes the existence of vesicular vapour, and makes the particles of clouds to be hollow spheres, which unite and descend in rain when ruptured, however sanctioned by the authority of several eminent philosophers, does not seem necessary to the science of meteorology in its present state; it being evident that the buoyancy of the particles is not more perfect than it ought to be, if we regard them as mere drops of water. In fact, they always descend, and the water is elevated again only by being converted into invisible vapour.

The height of the clouds is supposed to be from about a quarter of a mile to a mile. It is common for persons by climbing very high mountains, to get above the clouds, and see them swim beneath them. The wonderful variety in the colour of the clouds is owing to their particular situation with regard to the sun, and the different reflections of his light. The different figures of the clouds result from their loose and voluble texture, revolving into any form according to the varied force of the winds. Those small clouds, sometimes seen very high, and heaped upon one another, presage rain very soon. When the horizon, at the rising or setting of the sun, appears pale and yellowish, it is a sign of the air being full of vapours, and threatens bad weather. But when it is of a light red at those times, there are but few vapours in the air, and fine weather may be expected. The quantity of vapour evaporated at any degree of heat or wind, depends on the quantity of vapour already in the atmosphere.

COAL, a solid inflammable substance commonly used for fuel. There are various species, 1. *Pit Coal*, is a black, compact, brittle mass, which, according to Kirwan, consists of petrol or asphaltum mixed with argillaceous earth; seldom with calcareous; and frequently also with pyrites. 2. *Culm Coal*, this has a greater portion of argillaceous earth and vitriolic acid, with a moderate portion of petrol. It burns with a flame without being consumed. 3. *Slate Coal*, contains so much earth, that it looks like common slate; but burns with a flame. There are large quarries of it at Purbeck, in Dorsetshire. 4. *Cannel Coal*, or ampelites, is of a dull black colour, and burns with a bright flame, but is apt to fly to pieces in the fire. This kind is used for making various toys, which appear like jet. 5. *Kilkenny Coal*, is the lightest of all, and contains the largest quantity of asphaltum; burns with less smoke and flame, and more intensely, though more slowly, than cannel coal. 6 *Sulphurous Coal*, has a considerable portion of pyrites, whence it is apt to moulder and break when exposed to the air, after which water will act upon it. There are in it yellow spots resembling metal. 7. *Bovey Coal*, is of a dark brown colour, and of a yellow lamina and texture. The laminæ are flexible when first dug, but harden when exposed to the air. It consists of wood penetrated with petrol or bitumen, and frequently contains pyrites, alum, &c. 8. *Jet*. This substance is found in France, Spain, Germany, Britain, and other countries. It is found in detached kidney-formed masses of various sizes, and is of a very deep glossy black colour, opaque and hard.

COAL, *Small*, a sort of charcoal prepared from the spray and brush-wood stripped off from the branches of coppice wood, sometimes formed in bavins for that purpose, and sometimes charred without binding. It is used by artificers to temper and anneal their works.

COAL GAS, is of the highest importance, from the beautiful light which it yields. When coals are burning on the fire, we see the stream shooting out, and inflaming when a light is held near it: this is coal gas. To obtain gas, the coals are enclosed in iron retorts, which are heated red-hot; the coal is literally dissolved, and the gas rising up in the retort, is made to pass through water and other substances, to free it from impurities. It is collected in a gasometer, from which it is transmitted by pipes to whatever distance it may be required, with the same facility as if it were water from a reservoir; indeed, with greater ease, as the level of a reservoir of water must always be higher than the place to which water is conducted; but from the buoyancy and lightness of gas, it will ascend to any height to which it may be desirable to conduct it. The gas produced from coal is chiefly the carburetted hydrogen gas, which consists of carbon and hydrogen, chemically combined. This is, however, by no means in a state of purity, but is only the predominant gas in the mixture.

COASTING, is that part of navigation which is carried on near the coast or shore, without losing sight of land, except occasionally for a short period.

COAT OF ARMS, in Heraldry, was a habit worn by the ancient knights, over their armour, reaching as low as their navel. The term is used for the bearing of a person or family.

COATING, the application of clay or some other substance about a glass vessel, to keep it from breaking by the violence of the fire.

COBALT, in Chemistry, a metal, when pure, of a white colour, inclining to bluish or steel gray. At the common temperature its specific gravity is more than 8·5. It is attracted by the magnetic needle, and is itself capable of polarity. For fusion, it requires nearly the same intensity of heat as cast iron. Cobalt occurs in nature alloyed with other metals, and mineralized by oxygen, and by arsenic acid. The white cobalt ore is an alloy of cobalt and arsenic, with a little sulphur, and in some specimens a little iron, the two latter being probably accidental. The gray cobalt ore, as it has been named, is an alloy of cobalt with arsenic and iron; sometimes, also, as has been affirmed, with small portions of nickel and bismuth.

Cobalt combines with many of the metals. Its alloys are generally brittle, and none of them have been applied to any use; nor have they been much examined. The principal, or indeed almost the sole use of cobalt, is in communicating a blue colour to glass, enamel, and porcelain. Smalt and azure blue are merely cobaltic glass in fine powder. Zaffre is a flint powder, and an impure oxide of cobalt prepared by calcination of the ores.

COBITIS, *the Loache*, a genus of fishes, of the order of abdominales, of which there are five species, natives of the rivers in Europe. The loache generally keeps at the bottom on the gravel, whence it is called the groundling.

COBOOSE, the place where the victuals are cooked on board merchant ships.

COCCULUS INDICUS, a poisonous berry, too frequently mixed with malt liquors to make them intoxicating. It is the fruit of the monospermum cocculus.

COCCUS, a genus of insects belonging to the order of hemiptera. The coccus cacti, a native of the warmer parts of

America, is the famous cochineal animal. The female, which alone is valuable for its colour, is slothful and ill-shaped. The male is scarce, and sufficient for three hundred females. It is small, slender, and active. The cochineal insect resembles the silkworm in the manner of depositing its eggs. The insects destined for this purpose are taken and put into a box lined with a coarse cloth, where they lay their eggs, and then die. The box is kept close shut till the time of placing the egg on the foliage of the cactus cochenilifer or Indian fig, called by the Spaniards nopal. At Oaxaca, in Mexico, the cochineal insects are gathered in large quantities, and the cultivation of them is the employment of the Indians. In trade there are four sorts of cochineal – mastique, campeschane, tetraschale, and sylvester. The first is the best, and the last the worst. The cochineal is esteemed in medicine as a cordial, sudorific, and febrifuge; but it is chiefly used by dyers and painters. Coccus lacca, or gum lac animal, is a native of the East Indies. This species fix themselves upon the succulent extremities of the young branches of the trees they inhabit, and are as it were glued thereto by a red liquid, which gradually accumulating, forms a complete cell, and is what is called gum lac. Out of this proceed the young insects, leaving the exuviæ behind, which is that white membranous substance found in the cells of the stick lac. The gum lac brought to this country is principally found on the mountains on both sides the Ganges, and is of a deep red colour. Coccus Polonicus, or the scarlet grain of Poland, is usually met with at the root of the plant called polygonum cocciferum.

COCHINEAL, was at first supposed to be a grain, which name it still retains by way of eminence among dyers, but naturalists soon discovered that it was an insect, a species of the coccus. Fine cochineal, which has been well dried and properly kept, ought to be of a gray colour inclining to purple. The gray is owing to a powder which covers it naturally, a part of which it still retains: the purple tinge proceeds from the colour extracted by the water in which it has been killed. Cochineal will keep a long time in a dry place. Hellot says, that he tried some 130 years old, and found it to produce the same effect as new.

COCHLEA, the same as screw: being thus called in consequence of its resemblance to the spiral shell of a snail, called by the Latins *cochlea.*

COCKBOAT, a small boat used on rivers near the shore. In ancient days a cock was the general name of a yawl.

COCKPIT, in a ship, is near the apartments of the surgeon and his mates, being the place where the wounded men are dressed. It is situated near the after hatchway, and under the lower gun-deck.

Fore COCKPIT, a place leading to the magazine passage, and the boatswain's, gunner's, and carpenter's store rooms; in large ships, and during war time, the boatswain and carpenter generally have their cabins in the fore cockpit, instead of being under the forecastle.

COCOS, in Botany, a genus belonging to the natural order of palmæ, and of the monoecia hexandria class. There are five species. The principal is, cocos nucifera, or cocoa-nut tree. It frequently grows to the height of sixty feet, and is smaller in the middle than at top and bottom. Owing to the load of nuts which it bears, it leans to one side. The colour is of a pale brown, and the bark smooth. The leaves are often fourteen or fifteen feet long, and about twenty-eight in number. The nuts hang at the top of the trunk in clusters of a dozen each. The nut has, next the stem, three holes closely stopped. When the kernel begins to grow, it incrusts the inside with a substance like jelly; this hardens and increases till it becomes white. The quantity of liquor in a full-grown nut is about a pint, and is pleasant to the taste. The husky tegument of the nut consists of tough, stringy filaments, like coarse oakum. The leaves are made into brooms, mats, sacks, and other useful articles.

CODE, a collection of the laws and constitutions of the Roman emperors, made by order of Justinian.

CODEX, a book or tablet, used by the ancients.

CODICIL, a writing, added by way of supplement when a thing has been omitted, that the testator wishes to appear in his last will.

CO-EFFICIENTS, in Algebra, are numbers or letters prefixed to other letters, or unknown quantities, into which they are supposed to be multiplied; and, therefore, with such letters, or the quantities represented by them, making a product, or co-efficient product. *See* ALGEBRA.

COFFEA, or the COFFEE TREE, a genus of the monogynia order, in the pentandria class of plants, ranking in the natural method under the 47th order stellatæ. There are 10 species, the principal of which is a native of Arabia Felix, which rises about 16 or 18 feet in height: the main stem growing upright, is covered with a light brown bark; the branches are produced horizontally and opposite, crossing each other at every joint. The leaves also stand opposite, and when full grown, are about four or five inches long, and two broad in the middle, decreasing towards each end: the bodies are waved, and the surface is of a lucid green. The flowers, which are white, are produced in clusters at the root of the leaves, sitting close to the branches. The fruit resembles a cherry. It grows in clusters along the branches, under the axillæ of the leaves. It is at first of a green colour, and when of a deep red, is gathered for use. The coffee tree is cultivated in Arabia, Persia, the East Indies, and America. It is also raised in botanic gardens, in several parts of Europe. Coffee is said to assist digestion, and is good in relieving the headache: and for very weak constitutions, should be drank immediately after dinner. It is taken in large quantities by the Turks and Arabs.

COFFER, in Fortification, is a hollow lodgment across a dry moat, on which are raised pieces of timber, and hurdles filled with earth, serving as a parapet with embrasures. The use is for the besieged to defend the ditch, and to repulse the besiegers.

COFFER DAM, a term applied by engineers to denote the enclosures formed for laying the foundation of piers and other works in water, to exclude the surrounding fluid, and thus forming a protection both to the work and workmen.

COGNATION, in Civil Law, a term for that line of consanguinity between males and females, both descended from one father.

COGNISOR, in Law, one that passeth or acknowledgeth a fine of lands or tenements to another.

COGNOVIT ACTIONEM, in Law, is an acknowledgment by a defendant, or confession, that the plaintiff's cause of action is just, and therefore suffers judgment to go against him.

COG WHEEL. Wheels acting upon each other are the instruments by which the transmission of mechanic force from one part of a system of machinery to another is commonly and conveniently effected. The due connexion of the moving parts is accomplished either by the mutual action of properly formed teeth, in some instances called *Cogs,* by straps or endless bands, or, by the friction of one face of a wheel against another.

Among the ingenious inventions of the present day, for the communication of motion in machines, in lieu of the ordinary cog or toothed wheels, the invention of Lewis Gompertz, Esq. of the Kennington Oval, Surry, is so perfectly original as to require the most extensive publicity. The following is its description in the words of the inventor's specification of the patent which he obtained for this improvement in the arts, dated April 27th, 1814.

"One of the wheels I call the pin wheel, because it is provided with pins, marked B C D E, see *Plate,* figs. 1, 2, and 5, which pins may be furnished with friction rollers, and which project perpendicularly from its plane, and communicate motion to the other wheel, called the curve wheel, (or *vice versa,*) by entering curved grooves G H I K, made in the surface of it, as shewn in the perspective view, fig. 5. The axes, and consequently the planes of the two wheels, are so inclined to each other, that the ends of the pins B C are beneath the surface of the curve wheel, and therefore enter into the grooves. But, in consequence of the inclination of the wheels as the pins approach the point D, or come to the line between the centre of the wheels, their ends come to the surface of the wheel, so as to leave the grooves; and as they proceed towards E, they are so completely above the wheel as to pass over without touching it. The manner of action is this: the pin C is engaged in the groove G, and the pin B is on the point of entering H; by the revolution of the pin wheel its pins B and C act in the grooves

SUBSTITUTES FOR COG WHEELS, BY L. GOMPERTZ ESQ

Fig 1

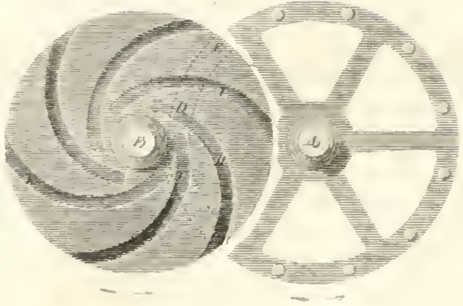


Fig 2

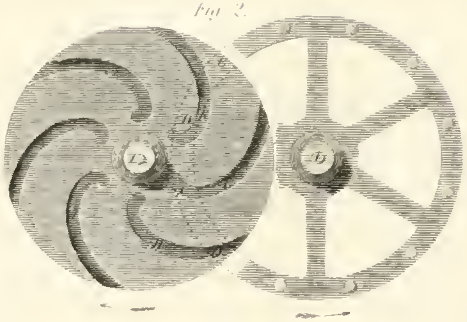
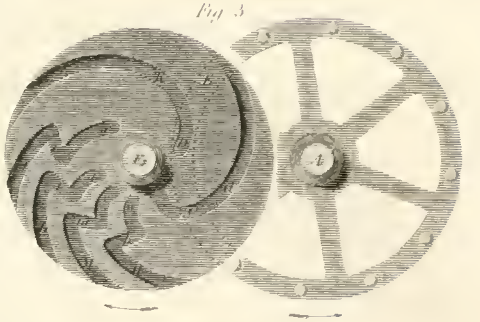
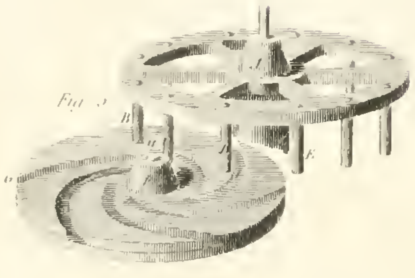
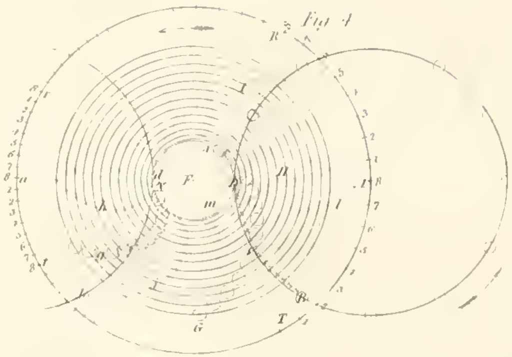
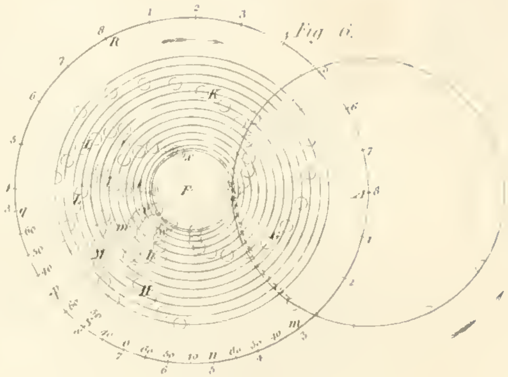


Fig 3



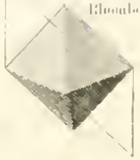




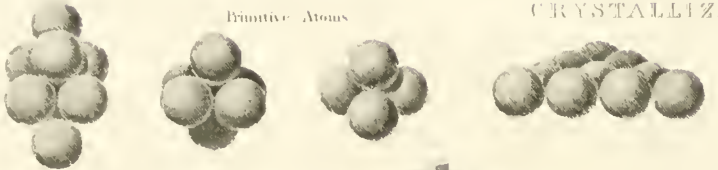


CRYSTALLIZATION. p 206

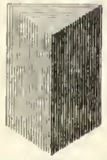
Acute Rhomboid



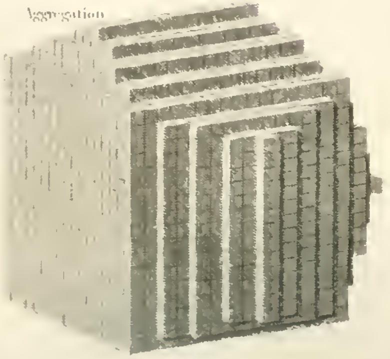
Primitive Atoms



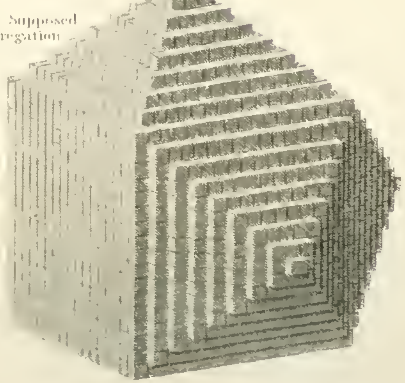
Prism



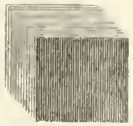
Aggregation



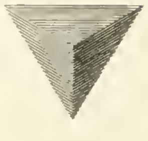
Supposed Aggregation



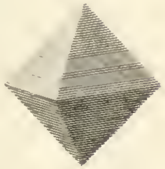
Cube or Parallelepipedon



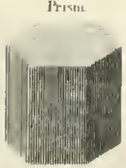
Tetrahedon or Simplest Pyramid



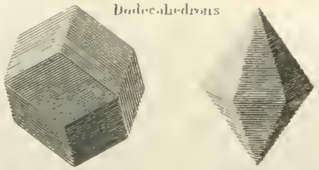
Octohedron



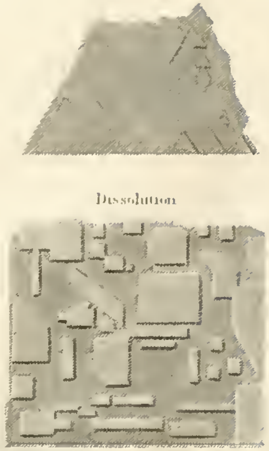
Hexangular Prism



Dodecahedrons



Dissolution



J. Lowry sculp

and pressing in their curves, turn the curve wheel round upon its centre; and as the pins in succession quit the grooves in the same manner as the pin D is supposed to have quitted the groove K, the other pins very soon after enter the next groove but one, in the same manner as B is entering into H, and by this means, before any pin leaves its groove, the succeeding pin has just entered, and a constant action of the pins in the groove is kept up. The law of the actioo depends upon the nature of the curves, which may be varied at pleasure, so that they will turn each other with an equal velocity, and with a perfect regular motion; or by an irregular one, or the curves may be made to turn with twice or three times the velocity, or in almost any ratio required, also to turn each other in either direction; thus, in figs. 1 and 5, both the wheels turn round in the same direction as shewn by the arrows, but in fig. 2 the grooves are differently curved, and they turn contrary ways to each other. A manner of finding the curves for these grooves is explained in fig. 4. First describe the circle F *l*, for the size of the curve wheel; then draw a circle, A B C D, for the pin wheel, and divide it into the number of pins it is intended to have, for example twelve; subdivide the spaces between each of the pins D C and C B into any number, eight for example, and figure the divisions, as shewn next; on the centre F draw a circle through each of the said divisions, also a circle A R T passing through the centre of the pin wheel. Now, divide the circumference of this circle into as many parts as the wheel is to have curves, this will depend upon the ratio the velocities of the wheels are to bear to each other; thus, if it is to turn twice for once of the pin wheel, there must be half as many curves as there are pins; therefore in the drawing, the circle A R T is to be divided into 6, and each sixth is subdivided into as many equal parts as the spaces C and D were *viz.* eight. These spaces are to be numbered as shewn. With this preparation proceed to set out the curves, by taking the radius A D in the compasses, and setting one point in the division marked 3, between T and A; make a mark at , upon the external circle, also numbered 3, towards that side where the curve wheel is to be elevated, (by *side*, is not meant side of the wheel, but side of the position of the wheel, or of absolute space, as the wheel changes in turning, and what is high in one instance is low in the next,) because it passes through the division 3, between B and C. This mark will be the first point of one of the curves. Then, from the division 4, mark the circle 4 for the second point; next from the point 5 to the circle 5; and so on through the whole number of circles. This will find a number of points, forming a curve G C *x*, which will be the centre line of the intended groove. And to find its breadth, describe small circles round each of these points, rather larger than the pins, as drawn. The edges of the grooves may then be drawn as tangents to these circles. The succeeding curves H and I are found in exactly the same manner from the succeeding divisions on the great circle, beginning on the division 3, between A R, and so on all round. On the opposite side of the circle are shewn curves *g h i*, proper for giving the curve wheel an equal velocity with the pin wheel, and there will therefore be twelve of these curves in the whole. The preparation is exactly the same, but the great circle instead of six is divided into twelve, as at the points *a r* and *t*, and each of these are subdivided into eight (or the same number as between *d* and C;) then the curves are set out from these points exactly as before: in both these cases the wheels are considered as revolving in the same direction, as shewn by the arrows figs. 1 and 5. If it is required that they should turn each other in opposite directions, the curves must be reversed, as shewn in fig. 2. To set out these curves, the same lines and divisions as in fig. 4 are used; but the division between T A and A R must be figured the contrary way, namely, beginning at R and proceeding to A; then setting one foot of the compasses at 5, between A and R, and the other leg in the first circle (marked 3) towards that side where it is meant to be elevated, and as one leg is moved towards T, move the other leg towards the centre; and for the next curve begin with the next same number towards T, and so on, and mark as before. A reverse curve will here be produced, as shewn dotted at *l* C *m*, and a wheel, constructed with these curves, as in fig. 2, will turn in a contrary direction to the pin wheel, as shewn by the arrows.

"Fig. 3 represents a curve wheel, with six curves, which therefore revolve twice for once of the pin wheel; but the curves are so arranged, that for two-thirds of its revolution the curve wheel revolves at the rate of four to one of the pin wheel, *viz.* while the pins are acting in the curves G and K, the four remaining curves I L M H are close together, and the action of the pins, when in them, only advances the curve wheel double the space of the pin wheel; but the motion of the curve wheel, even while the pins are acting in these grooves, may be mado irregular, to almost any required law; thus, at the external parts I L M, where the pins first enter, the grooves are curved the same as fig. 2, and therefore the pins will in these positions turn the curve wheel twice as fast as they move themselves, but on entering and moving through the returned parts *i l m* of the curves, the pin communicates a recoiling motion to the curve wheel, which continues till the pin enters the last portions *t v w*, and at the same time a succeeding pin enters the next curve; this again actuates the curve wheel, as in the first instance.

"This wheel is set out on the same principle as the others, see fig. 6, which is prepared exactly as before, except the dividing of the great circle, which must in all cases be done according to the motion the curve wheel is intended to have given to it; in the present instance it is first divided in 3, at A R S, and each of these subdivided into eight; then from No. 3, between R and A, mark on the outside circle 3; from 4 to the circle 4; and so on till the curve G is brought as far as the next circle marked 3, from which place only move the leg in the large circle half a division; then set out K, by following the same process on another part of the great circle, excepting that the leg in the large circle is continually to be moved a whole division. To obtain the four other curves, take the space from fig. 3 *m* to 3 *q*, which is one-third of the whole circle, and divide it into four, *viz.* at *m n o p q;* then each of these spaces being subdivided into four, as shewn by the figures 40, 50, and 60, produce the curves thus: begin at *m*, and mark on the external circle for the first division of H, then from 40 mark on the circle 4, and continuing this till six circles, towards the centre, are marked, and the curve H is finished; this will have brought the compasses to one division beyond *n;* for the returned part *h* mark the two next circles towards the centre, and by returning one division for each in the large circle, this brings the compasses back to 60, and advancing from that point, begin the interior part *w*, and also the part M of the next curve, which is completed by a repetition of the same process on the succeeding part of the circle, as is likewise L and I *i;* but the interior end *x* of the latter must be set out from the great divisions of the circle R S; thus, when the part *i* is ended from 69 next to *q* 3, advance the compasses to the points 4, 5, 6, and 7, for marking the successive circles till the curve is completed.

"This is given only as an example of the manner of making a wheel to turn with any required degree of irregularity in its motion; but I claim all varieties of curves which may be made to act on the principles I have described, to communicate regular or irregular motion from the pins of a wheel."

COHESION, that species of attraction, which, uniting particle to particle, retains together the component parts of the same mass; being thus distinguished from *adhesion*, or that species of attraction which takes place between the surfaces of similar or dissimilar bodies.

Whatever may be the cause of cohesion, its effects are evident and certain, and the different degrees of it is what constitute bodies of different forms and properties; at least, this is the opinion of Sir Isaac Newton, and other eminent philosophers.

Various experiments have been made by different authors, to ascertain the power of cohesion, in bodies of different textures; as woods, metals, glass, &c. These experiments have generally been made on cylindric bars, an inch, or certain parts of an inch, in diameter; and as it has been proved, that the direct cohesive strength of a body is in the joint ratio of its primitive elasticity, toughness, and area of its section, it follows, that having ascertained the cohesive power with any given section, the same may be found for the same substance for any other section, and thus the experiments of different authors compared with each other.

The following table shews the weights which were necessary to tear asunder rods of different substances, whose bases were each a square inch, the weights being applied in the direction of their length.

METALS	lbs. Avoirdupois.	WOODS	lbs. Avoirdupois.
Steel,	135000	Beech, oak,	17300
Iron bar,	74000	Alder,	13900
Cast iron,	50100	Elm,	13200
Copper, cast,	28600	Mulberry,	12500
Silver, ditto,	41500	Willow,	12500
Gold, ditto,	22000	Ash,	12000
Tin, ditto,	4000	Plum,	11800
Bismuth,	2900	Elder,	10000
Zinc,	2600	Fir,	8330
Antimony,	1000	Pitch, pine,	7656
Lead, cast,	860	Cypress,	6000
		Poplar,	5500
		Cedar,	4880

Other experiments have been made to ascertain the strength of cohesion in bodies, when placed horizontally, and loaded with weights in different parts; but as we shall have occasion to return to this subject under the article STRENGTH of *Materials*, we shall, in this place, merely state the result of Muschenbroek's experiments on a few of the most common woods. For this purpose he fixed pieces of wood, by one end, into a square hole in a metal plate, and hung weights towards the other end, till they broke at the hole. The weights, and their distances from the point of support, are shewn in the following table :—

WOODS.	Dist. in Inches.	Weight in oz.
Pine,	9½	36½
Fir,	9	40
Beech,	7	56½
Elm,	9	44
Oak,	8½	48
Elder,	9¼	48

In the above table the rods were rectangular parallelopipedons, and the side of their square section ·26 of an inch.

Coulomb found the lateral cohesion of brick and stone only $\frac{1}{44}$ more than the direct cohesion; which, for stone, was 215 lb. for a square inch; for good brick, from 280 to 300. Count Rumford found the cohesive strength of a cylinder of iron, an inch in diameter, 63466, or 63173 lb.; the mean, 63320; which is only $\frac{1}{20}$ more than Emerson's result. Sickingen makes the comparative cohesive strength of gold, 150955; of silver, 190771; of platina, 262361; of copper, 304696; of soft iron, 362927; of hard iron, 559880. Guyton makes platina a little stronger.

COILING, is a sort of serpentine winding the ropes, by which they occupy a small space, and are not liable to be entangled amongst one another in working the sails. Each winding of this sort in a cable is called a fake, and one range of fakes is called a tier; there are generally from five to seven fakes in a tier, and three or four tiers in a cable's length: the small ropes are frequently coiled by hand, and hung upon cleats to prevent their being entangled amongst one another, in traversing, contracting, or extending the sails.

COINING, the art of making money, is performed either by the hammer, or the mill and steam-engine. By either of these methods the pieces of metal are stamped or struck with punches or dies, on which are engraven the sovereign, effigies, arms, legend, &c. The puncheon consists of a highly tempered piece of steel, upon which the coin is sunk in relievo, and again upon the matrix, which is another piece of steel some four inches long, formed square at the bottom, and rounded at its top. The moulding of the border and letters is added on the matrix with small and sharp steel puncheons, and when it is thus finished, it is called the die. In coining with the mill, the bars or plates of gold or silver, after having been moulded, and taken out of the mould, are scraped and brushed, and passed several times through the mill to flatten them, and bring them to the just thickness of the specie to be coined. But the plates of gold are heated again, and quenched in water before they pass through the mill, which renders them more ductile: those of silver pass the mill just as they are, without any heating; and when afterwards heated, they are left to cool. The plates thus reduced as nearly as possible to their thickness, are cut into round pieces the size of the intended specie. The cutting instrument has its upper end formed into a screw; which being turned by an iron handle, lets the steel, well sharpened, in form of a punch-cutter, fall on the plates; and thus a piece is punched out. These pieces are now adjusted, and brought, by filing or rasping, to the weight of the regulated standard; what remains of the plate between the circles is melted again. The pieces are adjusted in a fine balance; and those too light are separated from those which are too heavy; the first to be again melted, and the second to be filed down. The mill through which the plates pass can never be so just but there will be some inequality.

The pieces are called blanks, and are carried to the *blanching* or *whitening-house*, where the gold pieces have their colour given them, and the silver ones are whitened. This is done by heating them in a furnace, and when taken out and cooled, boiling them successively in two copper vessels, with water, common salt, and tartar, and after that scouring them well with sand, and washing them with common water, drying them over a wood fire, in a copper sieve, into which they are put when taken out of the boilers. In England, the standard for gold is eleven parts of pure metal and one of alloy; for silver, 11 oz. 2 dwts. of pure silver, and 18 dwts. alloy, making together 1 lb. troy weight.

In the machinery invented for coining, by the late Messrs. Boulton and Watt, and lately introduced into the Royal Mint. London, the screw presses for cutting out the circular pieces of metal, are worked with great facility, and both the edges and the faces of the money are coined at the same time, with such superior excellence, and cheapness of workmanship, as will prevent clandestine imitation, except in a very limited degree indeed. By means of this machinery, four boys can strike 30,000 pieces of money in an hour: the machine acting at the same time as a register in keeping an unerring account of the number of pieces that have been struck!—*See* MINT.

COKE, a preparation of fossil coal, whereby it is deprived of the naptha, bitumen, or asphaltum, it may contain, so that when applied to certain purposes, it may not communicate a bad flavour or bad qualities. Coke is made in very large ovens, principally from the refuse of brush-coal, with which some pits abound; the coal in them being extremely brittle, and rarely coming away in large pieces. In great towns which are lighted with gas, coke is obtained in great abundance from the gas-works, being left in the retorts after the gas is driven off by the heat.

COLD, in common language, denotes the sensation which is felt, or the effect which is produced, by the abstraction of heat; that is, heat and cold are opposite to each other, and the existence or increment of the one, is equal to the want or decrement of the other; so that the same degree of temperature may be called hot or cold, according as it is compared with a colder or hotter temperature. Thus the climate of Great Britain is a cold climate, in comparison with that of the West India islands; and a hot climate, in comparison with that of Siberia. If a man warms one of his hands near a fire, whilst he cools his other hand by means of ice; and if afterwards he plunges both his hands in a basin of water of the common temperature of the atmosphere, that water will feel cold to the hand that has been heated, and hot to the other hand. From this it appears, that cold is not any thing real, but merely a privation of heat; so that instead of saying, that a body has been cooled to a certain degree, it may with equal truth and propriety be said, that the body has been deprived of heat to that certain degree. *See* FREEZING.

Notwithstanding the simplicity of this theory, and the conviction which seems to accompany it, philosophers have often entertained doubts concerning it; and they have endeavoured to inquire into the real state of the matter, by devising experiments capable of demonstrating whether the cause of heat was any thing real, and that of cold only a privation or diminution of the former; or, *vice versa*, whether the cause of cold was any thing real, and that of heat a diminution; or, lastly, whether the production of heat, and the production of cold, were not owing to two distinct principles or elements. On the supposition that the cause of one of those effects only is real, it is much more natural to suppose, that the cause of heat is the real principle or element; since its effects, *viz.* enlargement of the bulk of bodies, the separation of their parts, &c. are such as must be produced by the introduction of something real; and the abstraction of this principle may naturally produce the effects of cold, such as contraction of the bulk of bodies, agglutination, &c.; whereas it would be unnatural to suppose, that a body contracts its bulk, as its parts come into closer contact, because something else has been introduced amongst them. With respect to the last supposition, *viz.* whether the effects of heat and those of cold be not owing to two distinct principles, a few arguments, and the equivocal result of a few experiments, have, at times, been adduced in support of it. But the general and prevailing opinion among the philosophers is, that a single element, called caloric, produces heat, or the effects of expanding bodies separating their parts, &c.; and that cold is only a relative expression; that is, meaning only the decrement of heat; so that real or absolute cold consists only in the total abstraction of caloric; and, that such a point, *viz.* the zero of heat, may be determined, has been shewn by the experiments, the discoveries, and the calculations of Irvine, Black, Crawford, and others; but it is impossible, in this place, to enter into an investigation of the methods made use of in determining this remarkable point. *See* ICE.

COLEOPTERA, the beetle tribe of insects, comprehending all those with four wings, the external pair of which are hard, rigid, and opaque, forming a kind of covering for the inner. There are 56 genera of this order.

COLIC, a severe pain in the lower venter, so called because the disorder was thought formerly to be in the colon. There are different kinds, as the windy colic, the bilious, the hysteric, the nervous, and the Devonshire colic.

COLLAR, an ornament consisting of a chain of gold, with devices and ciphers, worn by the knights of the different orders. *Collar of a ship*, is a rope fastened about the beakhead, into which the dead-man's eye is seized that holds the main-stay; also the rope wound about the head of the mainmast.

COLLATERAL, those relations which proceed from the same stock, but not in the same ascending or descending line.

COLLATION, is the giving or bestowing of a benefice on a clergyman by the bishop, who is the patron thereof.

COLLIMATION, LINE OF, on a telescope, is a line passing through the intersection of those wires that are fixed in the focus, and the centre of the object-glass.

COLLISION, in Mechanics and Physics, is the meeting and mutual striking of two or more bodies, one of which, at least, is in motion. The most simple of the problems relating to collision was that of a body proceeding to strike against another at rest, or moving before it with less velocity, or approaching towards it. In the mutual percussion of several bodies, the absolute quantity of motion of the centre of gravity is the same after as before the shock. Farther, when the bodies are elastic, the relative velocity is the same after as before percussion. All this, however, is upon the sopposition, that bodies are either perfectly hard, or perfectly elastic; but as there do not exist in nature any bodies which we know of, either the one or the other of these kinds, the usual theories are of little or no service in practical mathematics.

COLLYRIUM, a topical remedy for inflammations of the eyes. The best is a small portion of brandy and spring water.

COLONNADE, in Architecture, a peristyle of a circular figure, or a series of columns disposed in a circle, and insulated withinside.

COLOUR, in Natural Philosophy, is that property of bodies which affects the sight only; or that property possessed by the elementary rays of light, separated by any means whatever, of exciting in us different sensations according to their different refrangibility. Thus colour may be considered in two respects, as it regards bodies in general, and as it is produced by solar light. *See* OPTICS.

Before the time of Newton, the ideas of mankind concerning colour were very vague and unsatisfactory. The Pythagoreans called colour the superficies of bodies: Plato said that it was a flame issuing from them: according to Zeno, it was the first configuration of matter: and Aristotle said it was that which made bodies actually transparent,

Dr. Hooke imagined, that colour is caused by the sensation of the oblique or uneven pulses of light; which being capable of no more than two varieties, he concluded there could be no more than two primary colours. It was also an opinion, that the solar light was simple and uniform, without any difference or variety in its parts, and that the different colours of objects were made by refraction, reflection, or shadows. But Newton taught them the errors of their former opinions; he taught them to dissect a single ray of light with the minutest precision, and demonstrated that every ray was itself a composition of several rays all of different colours, each of which when separate held to its own nature, simple and unchanged by every experiment that could be tried upon it. Or, to be more particular, light is not all similar and homogeneal, but compounded of heterogeneal and dissimilar rays, some of which, in like instances, being more refrangible, and others less refrangible, and those which are most refrangible are also most reflexible; and according as they differ in refrangibility and reflexibility, they are endowed with the power of exciting in us sensations of different colours.

Newton's theory of light and colours is striking and beautiful in itself, and deduced from clear and decisive experiments. 1st. That lights which differ in colour, differ also in degrees of refrangibility. 2d. That the light of the sun, notwithstanding its uniform appearance, consists of rays differently refrangible. 3d. That those rays which are more refrangible than others, are also more reflexible. 4th. That as the rays of light differ in degrees of refrangibility and reflexibility, so they also differ in their disposition to exhibit this or that particular colour; and that colours are not qualifications of light derived from refractions or reflections of natural bodies, as was generally believed, but original and connate properties, which are different in different rays, some rays being disposed to exhibit a red colour and no other, and some a green and no other, and so of the rest of the prismatic colours. 5th. That the light of the sun consists of violet-making, indigo-making, blue-making, green-making, yellow-making, orange-making, and red-making rays; and all of these are different in their degrees of refrangibility and reflexibility; for the rays which produce red colours are the least refrangible, and those that make the violet the most; and the rest are more or less refrangible as they approach either of these extremes, in the order already mentioned; that is, orange is least refrangible next to red, yellow next to orange, and so on; so that to the same degree of refrangibility there ever belongs the same colour, and to the same colour the same degree of refrangibility. 6th. Every homogeneal ray, considered apart, is refracted according to one and the same rule, so that its sine of incidence is to its sine of refraction in a given ratio; that is, every different coloured ray has a different ratio belonging to it. 7th. The species of colour, and degree of refrangibility and reflexibility, proper to any particular sort of rays, is not mutable by reflection or refraction from natural bodies, nor by any other cause that has been yet observed. When any one kind of rays has been separated from those of other kinds, it has obstinately retained its colours, notwithstanding all endeavours to bring about a change. 8th. Yet seeming transmutations of colours may be made, where there is any mixture of divers sorts of rays; for, in such mixtures, the component colours appear not, but, by their mutually alloying each other, constitute an intermediate colour. 9th. There are therefore two sorts of colour, the one original and simple, the other compounded of these; and all the colours in the universe are either the colours of homogeneal, simple light, or compounded of these mixed together in certain proportions. The colours of simple light are, as we observed before, violet, indigo, blue, green, yellow, orange, and red, together with an indefinite variety of intermediate gradations. The colours of compounded light are differently compounded of these simple rays, mixed in various proportions: thus a mixture of yellow-making and blue-making rays exhibits a green colour, and a mixture of red and yellow makes an orange; and in any colour the same in specie with the primary ones, may be produced by the composition of the two colours next adjacent in the series of colours generated by the prism, whereof the one is next more refrangible, and the other next less refrangible. But this is not the case with those which are situated at too great a distance; orange and indigo do not produce the intermediate green, nor scarlet and green the intermediate yellow. 10th. The most surprising and wonderful composition of light is that of whiteness; there is no one sort of rays which can alone exhibit that colour; it is ever compounded, and to its composition all the aforesaid primary colours are requisite. 11th. As whiteness is produced by a copious reflection of rays of all sorts of colours, when there is a due proportion in the mixture, so. on the contrary, blackness is produced by a suffocation and absorption of the incident light, which being stopped and suppressed in the black body, is not reflected outward, but reflected and refracted within the body till it be stifled and lost.

This method of accounting for the different colours of bodies, from their reflecting this or that kind of rays most copiously, is so easy and natural, that his system quickly overcame all objections, and to this day continues to be almost universally believed. It is now commonly acknowledged, that the light of the sun, which to us seems perfectly homogeneal and white, is composed of no fewer than seven different colours, *viz.* red, orange, yellow, green, blue, purple, and violet or indigo. A body which appears of a red colour, has the property of reflecting the red rays more powerfully than any of the others; and so of the orange, yellow, green, &c. A body which is of a black colour, instead of reflecting, absorbs all, or the greatest part of the rays that fall upon it; and, on the contrary, a body which appears white, reflects the greatest part of the rays indiscriminately, without separating the one from the other.

Colours used in Drawing and Painting.—Red Colours are: Lakes. This term denotes those colours which are formed by the combination of alumine, or the oxide of tin, with the colouring matters of vegetables. The lakes chiefly used are red colours, of different qualities, according to the basis and colouring matter employed; and are known by the names of *Carmine, Florence-lake*, and *Madder-lake*.

Carmine, a very rich bright crimson colour, stands well in water. For the preparation of carmine, take four ounces of finely-pulverized cochineal, which pour into four quarts of rain or distilled water, boiled previously in a *pewter* kettle, and boil the whole for six minutes; add, during the boiling, two drachms of pulverized crystals of tartar. Eight scruples of Roman alum, in powder, must be then added, and the whole be kept on the fire one minute longer. As soon as the gross powder has subsided, and the decoction become clear, decant it into large cylindrical glasses covered over, and kept undisturbed till a fine powder is observed to have settled at the bottom. Then pour off the liquor from this powder, which is to be gradually dried. From the liquor still coloured, the rest of the colouring matter may be separated by the solution of tin, when it yields a carmine little inferior to the former.

Florentine-lake, the kind in general use, and known by the name of *lake*, is used in water, and also in oil, but does not stand; it is a very beautiful colour at first, and there is no substitute that will completely answer the purposes of lake. The best sort is prepared from the sediment of cochineal that remains in the kettle after making carmine, adding a small quantity of cochineal or brazil-wood, and precipitating the colouring matter with a solution of tin.

Madder-lake, a colour lately brought into use, is not so bright and rich a colour as the last-mentioned lakes. It has this valuable advantage, it stands much better, and answers many of the purposes of Florence-lake.

Rose-lake, generally called rose-pink, is made by a basis of chalk, coloured by Brazil or Campeachy wood. It does not stand, and is only used for house-painting and paper-hanging.

Vermilion, is a bright scarlet pigment, formed from sulphur and quicksilver; its brightness, and inclining to a crimson hue, denotes its goodness. It is a very useful colour in oil, and stands well; but as a water-colour it is apt to turn black.

Red lead or minium, is lead calcined till it acquires a red colour, by exposing it with a large surface to the fire. It is also made from *litharge*, a calx or oxide of lead; but it is not so good as when made directly from metallic lead. This colour is apt to become black, both in water and oil. It is therefore seldom used, but for very coarse purposes.

Indian red, is sometimes used instead of lake, and it might be useful, had it not the property of appearing stronger after some time. Never use it as a water colour. In oil, this effect does not take place.

Venetian red, is a native red ochre, rather inclining to the scarlet than the crimson hue; it differs little from the common Indian red. It is fouler, and chiefly used by house-painters.

Spanish brown, an earthy substance, found in the same state in which it is used; is nearly of the same colour as Venetian-red, but coarser. It is only used for the commonest purposes, though it does not change.

Light red, or burnt ochre, is common yellow ochre, heated red-hot, till the colour changes from a yellow to a red. It is an excellent colour, both in water and oil, having the quality of standing well.

Red chalk, the same substance used for drawing on paper, in the manner of a crayon, is very much like light red, and is used instead of it, for some purposes. It stands well, and is used both in water and oil.

Burnt Terra di Sienna, made by calcining raw terra di Sienna till it acquires a red colour, a very rich tint, and much used in water and oil, as it stands well in both.

Blue Colours.—Ultramarine, is prepared from *lapis lazuli*, by calcining and washing it very clean. When genuine, it is the brightest, the most beautiful of all colours, and stands well. It is much valued, and used in oil, and means have been found to levigate it sufficiently for water-colour drawings.

Ultramarine ashes, the residuum after washing the lapis lazuli, in which a portion of the ultramarine still remains, is very subject to be adulterated, and not so bright as ultramarine, being like that colour with a tint of red and white in it, yet when genuine it stands well.

Prussian blue, is iron combined with prussic acid. It is made in the following manner:—Two parts of purified potash are intimately blended with three parts of dried and finely pulverized bullock's blood. The mass is first calcined in a covered crucible, on a moderate fire, till no more smoke or flame appear; after this, it is brought to a complete, yet moderate ignition. Or equal parts of potash and finely powdered coals, prepared from bones, horns, claws, &c. are mingled, and heated in a covered crucible to a moderate redness. Either of these two calcined masses is, after cooling lixiviated with boiling water, and the lixivium filtered. Nothing remains now but to make a solution of one part of green vitriol and two parts of alum; and to add to it, while yet hot, the above lixivium, little by little however, and to separate the greenish-blue precipitate, which then forms, by means of a filtre. If afterwards a slight quantity of diluted muriatic acid be affused upon this precipitate, it assumes a beautiful dark blue colour. The operation is terminated by edulcorating and drying the pigment thus prepared. Prussian blue is an extremely beautiful colour when properly prepared, and stands tolerably well. Common Prussian blue is apt to contain some iron, which causes it to turn greenish or olive.

Verditer, a blue pigment, obtained by adding chalk or whitening to the solution of copper in aquafortis, is prepared by the refiners, who employ for this purpose the solution of copper, which they obtain in the process of parting, by precipitating silver from aquafortis by plates of copper. Common verditer is made in Sheffield and Birmingham, from the sulphate of copper. Verditer is only used for coarse purposes, and chiefly by paper-stainers. It has been sometimes called *Sanders blue*, from the term *cendres-blues*, or blue ashes.

Indigo, extracted from a plant called the anil, that grows in the East and West Indies, is not so bright as Prussian blue, but it has the advantage of being more durable. It is the blue generally used in drawings. It cannot be dissolved by water, but may by the sulphuric acid; it then forms *Scott's liquid blue*, used for colouring silk stockings, &c.

Smalt is a glass covered with cobalt, and ground to a fine powder. Its coarseness prevents its being used much for painting in oil or water. It is employed sometimes by strewing it upon a ground of oil paint. It is also used in enamel painting and the colouring of porcelain, as it stands well.

Bice, is smalt more finely levigated.

Yellow Colours.—Indian yellow, the brightest of all yellows for water-colours, is not durable. It is said to be procured from the urine of the buffalo. In India, it is a common and cheap colour; the natives using it for colouring their calicoes, which they do without any mordant, so that the colour is washed out again when the cloth is dirty.

King's yellow, is orpiment refined, a substance dug out of the earth, and consisting of sulphur joined to arsenic; it may also be prepared by subliming sulphur with arsenic. It is of a bright yellow, but does not stand well; it is a strong poison, and great caution must be used in employing it.

Naples yellow, a very durable and bright yellow, comes from Naples. It is prepared from lead and antimony.

Yellow ochre, an earth naturally coloured by oxide of iron, is a cheap colour, and not very bright, but valuable, because it stands well. Roman ochre is a superior yellow ochre, of a rich tint.

Dutch pink, formed of chalk, coloured with the juice of French berries, or other vegetables affording a yellow colour, does not stand, and is chiefly used for common purposes.

Gamboge, a gum brought from the East Indies, dissolves readily in water, and is a fine serviceable yellow. It is used only in water.

Masticot, an oxide of lead, prepared from calcining white lead, is very little used, the colour not being bright.

Gall stones. This is a hard substance, formed in the gall-bladders of oxen; or it may be obtained from the gall of other animals. It is a rich colour, but does not stand.

Raw Terra di Sienna, a native ochreous earth, brought from Italy, is a fine warm colour, and stands well.

French berries. A liquor may be extracted from these, useful as a stain for coarse purposes; but it does not keep its colour.

Turmeric root and saffron, may be used for similar purposes.

Orange-lake, is the tinging parts of arnatto, precipitated together with the earth of alum. It does not stand.

Brown pink, is the tinging part of a vegetable substance precipitated upon the earth of alum. It is a rich greenish yellow, but does not stand.

Green Colours.—There are few colours so useful as green; and it is, therefore, the practice with artists to form their greens by the mixture of blue and yellow, and by varying these, a vast variety of green tints are obtained.

Sap green, is the concreted juice of the buckthorn berries. It is used only in water, and is employed chiefly in flower-painting, colouring prints, &c.

Verdigris, is an imperfect oxide of copper, combined with a small portion of acetite, carbonic acid, and water. It is prepared in large quantities, chiefly in France, near Montpellier, by stratifying copperplates with the husks of grapes, yet under various fermentation, which soon grow acid, and corrode the copper. After the plates have stood in that situation for a sufficient time, they are moistened with water, and exposed in heaps to the air. The verdigris is scraped off from their surface as it forms. Verdigris is of a bluish-green colour, it has no body, does not stand, and is only used for coarse purposes; it answers best in varnishes.

Distilled verdigris, sometimes called crystilis verdigris, is prepared from common verdigris, by dissolving it in vinegar. It is of a very bright green, and is used chiefly for varnishes, and in colouring maps, &c.

Brown Colours.—Bistre, is the finer part extracted from the soot of burnt wood. It is used alone for sketches in water-colours, being a transparent water colour.

Roman bistre, is a very excellent but scarce kind of bistre, imported from Rome.

Cologne earth, a mineral substance of a dark blackish brown colour, is a very useful pigment; what is generally sold in the shops for Cologne earth is an artificial mixture.

Raw umbre, a native ochreous earth, of a light brown, stands well.

Burnt umbre, is only the last mentioned colour calcined in the fire. It then acquires a rich deep brown, and is of great use, being a fine colour, that stands well.

Asphaltum, used in oil, is of a very rich deep brown. It is a transparent or glazing colour that will not work in water, but when dissolved in turpentine, it becomes an useful substance for giving deep and spirited touches to drawings. The linens in which the Egyptians wrapped their mummies were dipped in asphaltum.

White Colours.—Flake white, is an oxide of lead, formed by corroding lead with vegetable acids, or vinegar.

White lead is the same as flake white, but of an inferior quality. It is the only white used in oil-painting, and is therefore a very useful colour; in water it always turns black.

Egg-shell white, and oyster-shell white, are only egg-shells or oyster-shells calcined; the animal gluten is thus destroyed, leaving the lime behind, which soon attracts the carbonic acid again from the atmosphere. Well-washed Spanish white, or common whitening, answers the same purpose.

Permanent white, is a white sold in the shops under this name, and it will not change; but great care must be employed in using it, as it is made from barytes, a deadly poison.

Black Colours.—Lamp black, the soot of oil, collected after it is formed by burning, is very generally used, both in oil and water, and stands perfectly well. Ivory black, the charcoal of ivory or bone, formed by giving them a great heat, while they are deprived of all access of air: it is used both in oil and water. Blue black, the coal from burning vine-stalks in a close vessel, is like ivory black, with a tint of blue.

Indian Ink.—The Indian ink is used in China for writing with a brush, and for painting upon the soft Chinese paper. It has been ascertained, both from experiment and information, that the cakes of this ink are composed of lamp black and size, with the addition of some perfuming substances, not essential to it as an ink. The fine soot obtained by holding a plate over the flame of a candle or lamp, and mixed up with clean size, makes an ink in every respect equal to the Chinese.

Colouring Prints.—Persons who wish to colour prints should wash them first with alum water, which will prevent the colour from sinking, besides giving a lustre and brightness to them. For this purpose, boil four ounces of alum in a quart of clear water, till the alum is dissolved.

COLOUR, in Physics, a property inherent in light, by which it excites different vibrations in the optic nerve, and which being sent to the sensorium, affect the mind with different sensations.

COLOURING, in Painting, the art of disposing the tints so as to produce either an imitation of the natural colours of the objects represented, or of force and brightness of effect.

COLUBER, a genus of serpents, of which there are ninety-seven species.

COLUMBA, *the Pigeon*, a genus belonging to the order of passeres, of which there are about seventy species, natives of different countries.

COLUMBA NOACHI, *Noah's Dove*, is one of the new constellations, situated still more to the south, directly below Lepus; and it lies on the west of Argo Navis and Canis Major, whence its place in the heavens may be easily found. There are twenty-six stars in this asterism; one of these is of the 2d magnitude, one of the 3d, two of the 4th, &c.

COLUMN, in Architecture, a round pillar, made to support and adorn a building, and composed of a base, shaft, and capital.

COLUMN, in the Military Art, a long and deep file of troops or baggage.

COLURES, in Astronomy, are two great circles passing through the poles of the world; one of them passes through the equinoctial points, Aries and Libra; the other through the solstitial points, Cancer and Capricorn; hence they are called the equinoctial and solstitial colures. They divide the ecliptic into four equal parts, and mark the four seasons of the year.

COLYMBUS, *the Diver*, in Ornithology, a genus of anseres, of which there are several species.

COMA, a preternatural propensity to sleep, which however the patient cannot enjoy, but wakes again immediately.

COMA BERENICES, *Berenice's Hair.* Berenice was the wife of Euergetes, a king of Egypt; and when he went upon a dangerous expedition, she vowed to consecrate her fine head of hair to Venus, if he returned in safety. Some time after the return of Euergetes, the locks, which were hung up in the temple of Venus, disappeared, and Conon, an astronomer, publicly reported that Jupiter had made them a constellation. The cluster of stars composing Coma Berenices, is very remarkable, there being so many of the 4th and 5th magnitudes. The boundaries and contents of this asterism are: north by Canes Venatici, east by Boötes, south by Leo and Virgo, and west by Leo and Ursa Major. This constellation contains 43 stars, ten being represented of the 4th magnitude, and the remainder of less magnitudes.

COMB, an instrument for disentangling flax, wool, hair, &c. Combs are made of the horns of bullocks, of elephant's teeth, tortoise shell, and box or holly wood. Bullocks' horns are prepared by sawing off the tips, then holding the horns in the flame of a wood fire till they become soft. In this state they are slit open on one side, and pressed in a machine; then plunged into water, from whence they come out hard and flat. They are next sawn into proper lengths, and to cut the teeth, each piece is fixed in a tool called a clam. The teeth are cut with a fine saw, or rather a pair of saws, and they are finished with a file. The process for making ivory combs is nearly the same as the above. A method has beeen recently invented for cutting combs by machinery.

COMBINATION, in Chemistry, the union of bodies of different natures thereby producing a new compound body.

COMBINATIONS, in Mathematics, denote the different collections that may be formed out of any given number of things, taking a certain number at a time, without regard to the order in which they may be arranged; and are thus distinguished from *permutations*, or *changes*, which have reference to the order in which the several quantities may be disposed.

1. *When only two are combined.*—One thing admits of no combination. Two, *a* and *b*, admit of only one, *viz. a b*. Three, *a*, *b*, *c*, admit of three, *ab*, *ac*, *bc*. Four, of six, *viz. ab*, *ac*, *ad*, *bc*, *bd*, *cd*. Five, of ten, *viz. ab*, *ac*, *ad*, *ae*, *be*, *bd*, *be*, *cd*, *ce*, *de*.

Whence the numbers of combinations of two and two only, proceed according to the triangular numbers, 1, 3, 6, 10, 15. 21, &c. which are produced by the continual addition of the original series, 0. 1. 2, 3, 4, 5, &c. And if n be the number of things, the formula for expressing the sum of all their combinations by two's, will be $\frac{n \, . \, \overline{n-1}.}{1 \, . \, 2}$

Thus, if $n = 2$; this becomes $\frac{2 \, . \, 1}{2} = 1$. If $n = 3$; it is $\frac{3 \, . \, 2}{2} = 3$. If $n = 4$; $\frac{4 \, . \, 3}{2} = 6$, &c.

2. *When three are combined together*, three things admit of one order, *a*, *b*, *c*. Four admit of four, *viz. abc*, *abd*, *acd*, *bcd*. Five admit of ten; *abc*, *abd*, *abe*, *acd*, *ace*, *ade*, *bcd*, *bce*, *bde*, *cde*. And so on according to the first pyramidal numbers, 1, 4, 10, 20, &c. which are formed by the continual addition of the former, or the triangular numbers, 1, 3, 8, 10, &c. And the general formula for any number n of combinations, taken by three's, is

$$\frac{n \, . \, n-1 \, . \, n.-2}{1 \, . \, .2 \, . \, 3.}$$

So if $n = 3$; it is $\frac{3 \, . \, 2 \, . \, 1}{1 \, . \, 2 \, . \, 3} = 1$. If $n = 4$; it is $\frac{4 \, . \, 3 \, . \, 2}{. \, 6} = 4$. If $n = 5$; it is $\frac{5 \, . \, 4 \, . \, 3 \, .}{6} = 10$.

Proceeding thus, it is found that a general formula for any number n of things, combined by m at each time, is $s = \frac{n \, . \, n-1 \, . n-2 \, . \, n.-\sqrt[3]{}, \&c.}{1 \, . \, 2. \quad 3. \quad 4.}$ continued to m factors or terms, or till the last factor in the denominator be m. So in six things combined by four's, the number of combinations is,

$$\frac{6 \, . \, 5 \, . \, 4 \, . \, 3}{1 \, . \, 2 \, . \, 3 \, . \, 4} = 15$$

3. By adding these together, the sum will be the whole number of possible combinations of n things, combined by two's, three's, four's, &c. And all the series are the co-efficients of the power n of a binomial, wanting only the first two, 1 and n, therefore the sum will be $\overline{1 \times 1}|^{n} - n - 1$, or, $2^n - n - 1$. If the number of things be five, then $2^5 - 1 = 32 - 6 = 26$.

4. *To find the number of changes and alterations which a number of quantities can undergo, when combined in all possible varieties of ways with themselves and each other, both as to the things themselves, and their order and position.*

One thing admits of one order or position. Two may be varied four ways, as *aa*, *ab*, *ba*, *bb*. Three quantities taken by two's, may be varied nine ways, as *aa*, *ab*, *ac*, *ba*, *ca*, *bb*, *bc*, *cb*, *cc*. In like manner four things taken by two's, may be varied 4^2, or 16 ways; and five things, by two's, 5^2, or 25 ways.

Thus also when taken by three's the changes will be n^3, and when taken by four's they will be n^4, and so generally when taken by n's they will be n^n, wherefore, adding all those together, the whole number of changes or combinations in n, things taken by two's, by three's, by four's, &c. to n's will be the sum of the geometrical series, $n + 1^2 + n^3 + n^4 \dots n^n$, which sum is $= \frac{n^n - 1}{n - 1} + n$. For example, if the number of things n be four, this gives $\frac{4^4 - 1}{4 - 1} \times 4 = \frac{255}{3} \times 4 = 340$.

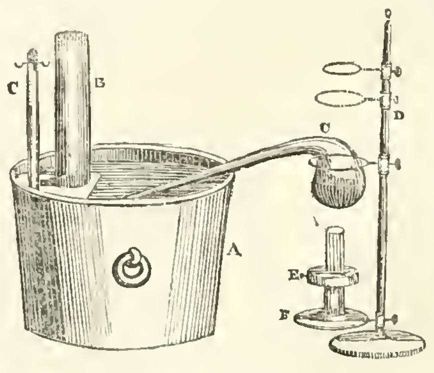
COMBUSTIBLE. A body which, in its rapid union with others, causes a disengagement of heat and light. To determine this rapidity of combination, a certain elevation of temperature is necessary, which differs for every different combustible. Combustibles have been arranged into simple and compound. The former consists of hydrogen, carbon, boron, sulphur-phosphorus, and nitrogen; besides all the metals. The latter class comprehends the hydrurets, carburets, sulphurets, phosphurets, metallic alloys, and organic products.

COMBUSTION was defined under the word Chemistry, to be the act of a body burning in a gas capable of supporting flame. We will here treat of these supporters of combustion; and first, they have the property of shining in the dark. Various kinds of animal and vegetable substances seem to have a great deal of this kind of phosphorus; the glow-worm is a remarkable instance. Dead fish, rotten sea-weed, and numbers of insects, have this property in a great degree. Instruments for measuring the degree or intensity of light, are called photometers.

Effects of Light upon the Photometer.

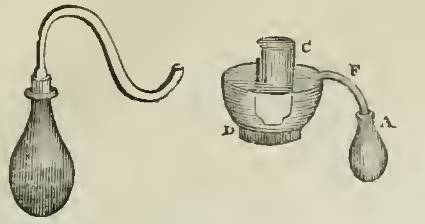
Light of the sun at an elevation of 30°, sky perfectly clear,	75°
Idem, sky white,	73°
Light of the blue sky at an elevation of 45°,	56°
Zenith,	49°
A cloudy sky,	53°
A full moon,	34°
Moon five days old,	20°
Light from snow enlightened by the sun,	57°
—— from snow in the shade,	47°
—— Starry sky, March 14, 1817,	7°
—— Sky clear of stars, March 14, 1817,	7° 5′
Planet Venus at an elevation of 30°, April 5, 1817,	9°

Simple Supporters of Combustion.—Oxygen. For the purpose of obtaining oxygen or any other gas, the annexed apparatus will prove the most elegant and generally useful. D is a stand with rings, supporting a retort C, and an Argand's lamp E; the latter is connected with the stand by a screw (see F); A is a pneumatic trough made of tin, and containing water, through which the gas proceeding from the retort, ascends into



the glass jar B, placed upon a wooden shelf;—as the gas ascends into the jar, the water is displaced. G is a strong tube of glass, in which gases are detonated or inflamed by electricity.

For common purposes, and where heat is not required, a matrass with a bent glass tube fitted to it, is used, as represented in the furthest figure. This may be done with a common phial and hand-basin, according to the nearest figure. A is the matrass; F the bent tube; C the phial; and D the basin.



Oxygen, is a substance known only in combination with other bodies, and has never been obtained alone. It is absorbed by combustible bodies, and converts them into acids. Oxygen is necessary for combustion, uniting itself always to bodies which burn, augmenting their weight, and changing their properties. It is necessary for the respiration of animals. It is a constituent part of atmospheric air, of water, of acids, and of all bodies of the animal and vegetable kingdoms. Combined with light and caloric, it constitutes oxygen gas. When a body has only a small quantity of oxygen united to it, not sufficient to make it an acid, it is called an oxide. Thus, most of the metals can only be reduced to the state of oxides by the addition of oxygen. This was formerly called calcination, and the metal added to oxygen was called a calx. Thus, the calx of mercury, of tin, &c. When the base has only just a sufficient quantity of oxygen to exhibit the properties of an acid, the termination *ous* is used, such as the sulphureous acid, the phosphorous acid, &c.; but when it has a greater portion of oxygen, the termination ends in *ic*, as sulphuric, phosphoric, and nitric acid.

Chlorine, is assimilated to oxygen as an elementary substance. In the gaseous state it is of a yellowish green colour, and it is this property which suggested its name. Its odour is extremely disagreeable. Chlorine is not capable of being respired; and even when mixed in very small quantities with common air, it renders it extremely pernicious to the lungs. It has never been found pure in nature; but exists in many compounds, particularly in table or sea salt.

Iodine, is obtained from sea-weeds, such as barilla and kelp: like chlorine and oxygen, when in the state of vapour, it supports combustion. Its vapour is of a violet hue: it is obtained in brown shining scales.

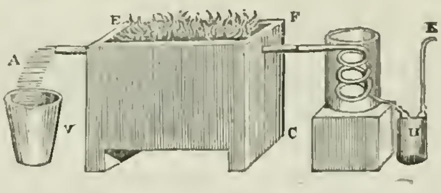
Fluorine, is the supposed base of fluoric acid obtained from fluor-spar; but it has never yet been obtained in a separate state.

Combustible and Non-combustible Substances.—Carbon. *Modern chemists consider the diamond as pure crystalline carbon.* The diamond is one of the hardest bodies known; for it resists the most highly tempered steel file, and can be ground or polished only by diamond powder. It takes an exquisite and lasting polish. It has a great refractive power; and hence its lustre, when cut into the form of a regular solid, is uncommonly great. The diamond, like other combustible bodies, burns by a strong heat, with a sensible flame, attracting oxygen, and becoming wholly converted into carbonic acid gas during that process. It combines with iron by fusion, and like common charcoal, converts it into steel. Common charcoal, the base of animal and vegetable matters, is widely diffused throughout nature. It is a compound of carbon with earths, alkalies, salts, &c. united to a portion of oxygen; it is properly an oxide of carbon. It is black, sonorous, and brittle; and is obtained from many substances, but chiefly from wood. When pure, it resists the greatest heat in close vessels. With nitrate of potash, it detonates in a hot crucible, leaving a fixed alkali behind. It does not mix with the metals, but restores their oxides to a metallic state.

Sulphur or brimstone, is a simple combustible substance, which nature frequently presents in a pure state. It is found in the earth in a loose powder, or in a solid state; and either detached or in veins. It is found also in the neighbourhood of volcanoes, and is deposited as a crust on stones contiguous to them. It is frequently met with in mineral waters, sometimes also in coal mines, and it is found in combination with most of the metals; when united to iron, it forms *martial pyrites*, or sulphuret of iron. In order to form it into rolls, it is melted and poured into wooden moulds; it is then called roll sulphur. Flowers of sulphur are formed by subliming purified sulphur with a gentle heat in close chambers. Sulphur is a non-conductor of electricity, and hence it becomes electric by friction—it unites to most of the metals; rendering them brittle and fusible.

Phosphorus, is commonly found united to oxygen, in the state of phosphoric acid, which is found plentifully in different animal, vegetable, and mineral substances. It is a yellowish semitransparent substance, of the consistence of wax. It is luminous in the dark, at the common temperature of the atmosphere. It takes fire spontaneously, and burns rapidly in the open air, (at 122° of Fahrenheit,) with a brilliant white flame, and is converted into phosphoric acid. The combustibility and luminous property of phosphorus have given birth to various experiments, and the following will evince its characteristic properties in a pleasing manner. That phosphorus burns at the usual temperature, appears by writing with it upon black or purple paper, or any other smooth surface. The writing will be luminous in the dark, as if on fire. The fiery appearance vanishes by blowing upon it, but becomes visible again after a few seconds. The combination of any substance with sulphur, phosphorus, or charcoal *without oxygenation*, has the termination of its name in *et*: thus sulphur and iron form sulphuret of iron, phosphorus and lime form phosphuret of lime.

Hydrogen. As hydrogen gas is produced by a different process from other gases, we insert the annexed cut. C is a furnace, through which an iron tube or gun barrel, E F, passes. In this tube there is a quantity of iron filings, over which the steam of water proceeding from a retort A, placed in a large crucible V, passes, and is decomposed; the oxygen of the water combining with the iron filings, whilst the hydrogen is set free, to pass through a vermicular tube R into a gas bottle H, and from thence by the tube K into any convenient receiver. Hydrogen is one of the constituent elements of water. It is also one of the ingredients of bitumen, of oils, fat, ardent spirits, ether, and in fact of animal and vegetable bodies; it also forms a part of all animal and vegetable acids; and it is one of the bases of ammonia, and of various compound gases. It possesses so great an affinity for caloric, that it can be obtained only in the state of gas. It is consequently impossible to procure it in the concrete or liquid state, independent of combination. Hydrogen united to caloric and light, forms hydrogen gas. Hydrogen gas united to carbon, forms carburetted hydrogen gas, by which streets, shops, theatres, and churches are lighted.



Nitrogen, called also azote, is a simple body, very abundant in nature, though not producible in an uncombined state. It is one of the component parts of atmospheric air, and also of all animal and vegetable bodies, nitric acid, and ammonia. It enters into combination with light and caloric. This compound is called nitrogen gas.

Boron, is a powder of a brown colour; inodorous and insipid; electric; incombustible in covered vessels, but increases in density when the heat is augmented; insoluble in ether, oils, alcohol, and water.

Silian, is a powder of a dark colour, incombustible at a high temperature.

COMET, an opaque, spherical, and solid body, like a planet, performing revolutions about the sun in elliptical orbits, having the sun in one of their foci. *See* ASTRONOMY.

COMMENDAM, a benefice or ecclesiastical living, which being void, or to prevent its becoming so, is committed *com-*

mendatur, to the care of a clerk, to be supplied till a proper pastor is appointed. When a person is made a bishop, his benefice is void by the promotion; but if the king give him power to retain it, he is said to hold it in commendam.

COMMERCE, in a general point of view, is usually distinguished into two kinds, the commerce of import and of export; but there is little reason for this distinction, for whatever a nation imports, it must have paid an equivalent for to the country of which it is purchased, and consequently the two branches are intimately dependent, and could not exist separately for any considerable period. The value obtained in foreign markets, for the goods or manufactures which a nation exports, repays the labour of procuring or manufacturing them, with a profit to the master manufacturer and to the exporting merchant; and this value being invested in foreign produce, which on importation affords a further profit to the merchant, it is evident that the transaction, while it supports individuals, makes a real addition to the wealth of the country, by the greater value of the returns imported beyond that of the goods exported. Commerce, therefore, while it is the means of procuring a mutual interchange of conveniences between distant countries, and of extending knowledge and civilization over every part of the globe, contributes essentially to the strength and influence of the countries by which it is encouraged.

COMMISSARY, in the ecclesiastical Law, an officer of the bishop, who exercises spiritual jurisdiction in places of a diocese so far from the episcopal see, that the chancellor cannot call the people to the bishop's principal consistory court, without giving them too much inconveniency.

COMMISSARY General of the Musters, an officer appointed to muster the army as often as the general thinks proper, in order to know the strength of each regiment and company, to receive and inspect the muster-rolls, and to keep an exact state of the strength of the army.

Commissary *General of Stores*, an officer in the artillery, who has the charge of all the stores, for which he is accountable to the office of ordnance.

Commissary *General of Provisions*, an officer who has the inspection of the bread and provisions of the army.

COMMISSION, in common Law, the warrant or letters-patent which all persons, exercising jurisdiction, have to empower them to hear or determine any cause or suit; as the commission of the judges, &c. Most of the great officers, judicial and ministerial, of the realm are made also by commission. By means of commission, oaths, cognizance of fines, answers in chancery, &c. are taken, witnesses examined, offices found, &c.

Commission *of Bankruptcy*, is the commission that issues from the lord chancellor, on a person's becoming a bankrupt within any of the statutes, directed to certain commissioners appointed to examine into it.

COMMITMENT, in Law, the sending of a person charged with some crime to prison by warrant or order. A commitment may be made by the king and council, by the judges of the law, the justices of peace, or other magistrate, who have authority by the laws and statutes of the realm so to do.

COMMITTEE of Parliament, a certain number of members appointed by the House for the examination of a bill, making report of an inquiry, process of the house, &c. When a parliament is called, and the speaker and members have taken the oaths, there are committees appointed to sit on certain days, *viz.* the committee of privileges and elections, of religion, of trade, &c. which are standing committees. Sometimes the whole House resolves itself into a committee, on which occasion each person has a right to speak and reply as often as he pleases, which is not the case when the House is not in a committee.

COMMON, is a right of privilege which one or more persons claim to take or use, in some part or portion of that, which another man's lands, waters, woods, &c. naturally produce, without having an absolute property in such lands, woods, waters, &c.

COMMON Law, that body of rules received as law in England, before any statute was enacted in parliament to alter the same.—The common law is grounded upon the general customs of the realm, including the law of nature, the law of God, and the principles and maxims of law. It is also founded on reason, as said to be the perfection of reason acquired by long study, observation, and experience, and refined by the learned in all ages. It may likewise be said to be the common birthright, that the subject has for the safeguard and defence not only of his goods, lands, and revenues, but of his wife, children, life, fame, &c. Our common law, it is said, after the heptarchy, was collected together into a body by divers of our ancient kings, who commanded, that it should be observed through the kingdom; and it was, therefore, called common law, because it was common to the whole nation, and before only affected certain parts.

COMMON PLEAS, one of the king's courts held in Westmister Hall, wherein a lord chief justice and three puisne justices preside. In personal and mixed actions it has a concurrent jurisdiction with the court of king's bench, but has no cognizance of pleas of the crown.

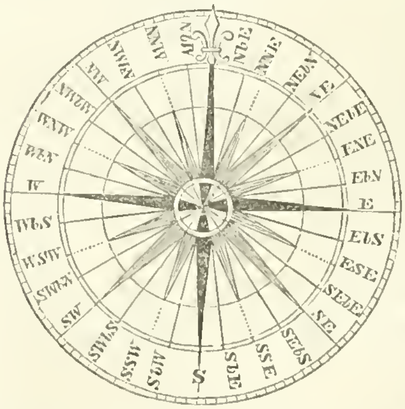
COMMONS, in Parliament, are the lower house, consisting of knights elected by the counties, and of citizens and burgesses by the cities and borough towns.

COMPANY, a society of merchants, tradesmen, or others, united in one common interest. When there are only two, three, or four, thus associated, it is called a partnership; the word company being usually restrained to a considerable number of members associated by prescription or charter. The mechanics of all towns incorporated are thus formed into companies, which have charters of privileges and immunities. In London they are numerous, and many of them are very rich. In a commercial sense, the term company denotes a large association formed for the purpose of trade; thus we have the Hamburgh company, the oldest trading establishment in the kingdom, incorporated in 1295; the Russia company, confirmed by charter in 1566; the Eastland company, settled in 1579; the South Sea company, formed in the reign of Queen Anne; the East India company, originally established in 1606; and, lastly, the Hudson's Bay company, first chartered in 1670.

Company, in the army, a body of foot commanded by a captain, who has under him a lieutenant and an ensign; the number of men from 50 to 80.

COMPARATIVE ANATOMY, is that which considers the bodies of other animals, serving for the more accurate distinctions of several parts, and supplying the defects of human subjects. Comparative, however, does not strictly stand in contradistinction to human anatomy; but while it embraces the whole circle of animated existence, considers man as the standard of its comparisons, and the primary object of its inquiries.

COMPARISON, in Rhetoric, a figure which illustrates one thing by resembling it to, and comparing it with, another, to which it has a manifest relation.



COMPASS, as represented in the annexed figure, an instrument employed by pilots to ascertain the ship's course at sea, consisting of a circular box, containing a paper card. The card, which represents the horizon, is divided into 32 equal parts, by lines drawn from the centre to the circumference, called points or rhumbs; the intervals between the points are also subdivided into halves and quarters, and also the whole circumference into equal parts called degrees, 360 of which complete the circle, and consequently the distance, or angle, comprehended between any two rhumbs, is equal to 11¼ degrees, or 15 minutes. The four principal points are called the cardinal points, two of which, opposite to each other, are called the north and south points; that which is toward the right hand when we look north, is termed the east, and its opposite the west point; the names of all the inferior ones are compounded of these according to their situation. Along the north and south line is fixed a small bar of steel, termed the needle, which, being touched by the loadstone, acquires a certain virtue, whereby it hangs nearly in the plane of the meridian, and consequently, determines the direction of the other points towards the horizon. This card and needle having a small socket in the centre, is supported on the point of a fine pin of steel, the whole being confined in the circular box, with a glass cover, which box is hung in gimbals to counteract the motion of the ship. A square box, with a moveable lid, serves to support the gimbals, and secures the compass from accident in removals.

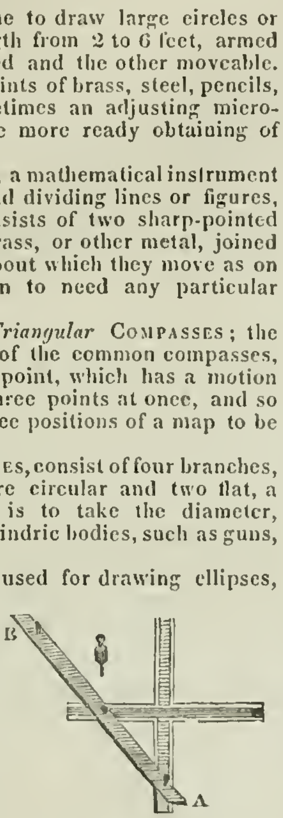
The "Board of Longitude" have voted £500 to Peter Barlow, for a very simple invention of curing the local attraction of ships, by placing *abaft* the compass, a plate of iron, which being regulated so as to correct the effects of the ship in any place, does the same in all places.

COMPASSES, Beam, a machine to draw large circles or arcs. The beam may be any length from 2 to 6 feet, armed with two cursors of brass, one fixed and the other moveable. These cursors may be formed of points of brass, steel, pencils, &c. and the fixed cursor has sometimes an adjusting micrometer screw applied to it, for the more ready obtaining of extents.

Compasses, or *Pair of Compasses*, a mathematical instrument for describing circles, measuring and dividing lines or figures, &c. The common Compasses consists of two sharp-pointed branches or legs, of iron, steel, brass, or other metal, joined together at the top by a rivet, about which they move as on a centre; and are too well known to need any particular description.

Compasses of *three Legs*, or *Triangular* Compasses; the construction of which is like that of the common compasses, with the addition of a third leg or point, which has a motion every way. Their use is to take three points at once, and so to form triangles, and lay down three positions of a map to be copied at the same time.

Cylindrical and *Spherical* Compasses, consist of four branches, joined in a centre, two of which are circular and two flat, a little bent at the ends: their use is to take the diameter, thickness, or caliber of round or cylindric bodies, such as guns, pipes, &c.



Elliptic Compasses. These are used for drawing ellipses, or ovals of any kind; they consist of a beam A B, about a foot long, bearing three cursors, to one of which may be screwed any point or pencil; to the bottom of the other two are riveted two sliding dove-tails, adjusted in grooves made in the cross branches of the instrument. These having a motion every way, by turning about the long branch, go backwards and forwards along the cross; so that when the beam has gone half way about, one of these will have moved the whole length of one of the branches, and when it has got quite round, the same dove-tail has got back the whole length of the branch; and the same may be repeated on the other side. The distance between the two sliding dove-tails is the distance between the two foci of the ellipsis; so that by changing that distance, any proposed ellipse may be described.

German Compasses, have their legs a little bent outwards, towards the top; so that when shut, the points only meet.

Hair Compasses, are so contrived within side, by a small adjusting screw to one of the legs, as to take an extent to a hair's breadth.

Proportional Compasses, are those in which the joint lies, not at the end of the legs, but between the points terminating each leg. These are either simple or compound. In the former sort the centre or place of the joint is fixed; so that one pair of them serves only for one proportion. In the compound ones the joint may be set at any distance, and consequently any proportion whatever easily obtained.

Spring Compasses, or *Dividers*, are made of hardened steel, with an arched head, which by its springs opens the legs; the opening being directed by a circular screw fastened to one of the legs let through the other, and worked with a nut.

Geometry of the Compasses, a species of geometry invented by M. Mascheroni, of Milan, by which all the elementary problems of plane geometry are performed by the compasses only, without the use of the ruler.

COMPLEMENT of an Arch or Angle, is what it wants of 90 degrees; thus the complement of 50° is 40°, and the complement of 40° is 50.

Arithmetical Complement, of a logarithm, is what the logarithm wants of 10·00000, &c.; and the easiest way to find it is, beginning at the left hand, to subtract every figure from 9, and the last from 10. So the arithmetical complement of 8·2501396 is 1·7498604. It is commonly used in trigonometrical calculations, when the first term of a proportion is not radius; in that case, add together the logarithms of the 3d, 2d, and arithmetical complement of the first term, and subtract 10 from the result.

Complement, in Astronomy, denotes the distance of a star from the zenith; or the arch comprehended between the place of the star above the horizon and the zenith, being the same as is otherwise called the co-latitude.

Complements of a *Parallelogram*, are the two smaller parallelograms made by drawing two right lines through a point in the diagonal.

COMPLEX Terms or Ideas, in Logic, are such as are compounded of several simple ones. *Complex Proposition*, is that which has at least one of its terms complex; or such as contain several members as casual propositions, or its several ideas offering themselves to our thoughts, by which we are led to affirm the same thing of different objects. Thus, neither kings nor people are exempt from death.

COMPLEXION, a term technically denoting the temperament, habitude, and natural disposition of the body; but popularly signifying the colour of the face and skin.

COMPOSITION, in Grammar, the joining of two words together; or prefixing a particle to another word, to change, or lessen, or augment its signification.—In Logic, composition is a method of reasoning, by which we proceed from a general truth to particular ones.—In Music, composition is the art of adapting sounds to airs, songs, &c. either in one or more parts, for the voice or instrument.—In Painting, composition denotes the choice and disposition of the figures of a picture.

Composition, in Commerce, a contract between an insolvent debtor and his creditors, by which the latter agree to take a part of the debt in compensation for the whole.

Composition, or *Composing*, in Printing, is the arranging of the types or letters in the composing-stick, in order to form a line; and of several lines ranged in order in the galley, to make a page; and of several pages, to make a form.

Composition *of Motion*, in Mechanics, is an assemblage of several directions of motion resulting from several powers, acting in different though not opposite directions.

Composition *of Proportion*, is the comparing the sum of the antecedent and consequent with the consequent, in two equal ratios, as, suppose 4 : 8 :: 3 : 6, they say by composition of proportion 12 : 8 :: 9 : 6. The same holds of the sum of the antecedent and consequent compared with the antecedent; thus we say, 12 : 4 :: 9 : 6. There is a great difference between composition of proportion by addition and by multiplication. *See* Proportion.

COMPOST, in Husbandry and Gardening, several sorts of soils or earthy matters mixed together, to make a manure for assisting the natural earth in vegetation.

COMPOUNDS, Primary, in Chemistry, are: 1. Alkalies, earths, oxides, acids, and compound combustibles. Secondary compounds are combinations of earths with each other, and with metallic oxides; combinations of earths with alkalies; combinations of acids with alkalies, earths, and metallic oxides; combinations of sulphuretted hydrogen with alkalies, earths, and metallic oxides; and lastly, combinations of oils with alkalies, earths, and metallic oxides.

COMPREHENSION, in Rhetoric, puts the whole for a part, or a part for the whole.

COMPRESSIBILITY, in Philosophy, that quality of a body or fluid, by which it yields to the pressure of another body or force, so as to be brought into a narrower compass. The compressibility of water was for a long time doubted by philosophers, and the famous Florentine experiment seemed for a time to decide the question in the negative. But water is really compressible into less than its natural bulk, and is more so in winter than in summer; but with spirits of wine and oil of olives, the contrary takes place, these being most compressible in the latter season. The following table shews the quantity of compression of these fluids and mercury, when the thermometer was at 50°, and barometer 29½ inches.

Compression of	Millionth parts.	Specific gravity.
Spirits of wine,	66	846
Oil of olives,	48	918
Rain water,	46	1000
Sea water,	40	1028
Mercury,	3	13595

Whence these fluids are not only compressible, but elastic; but that their degree of compressibility is not, as might have been expected, in the inverse ratio of their densities.

COMPUTATION, the method of estimating time, weights, measures, &c.

CONCAVE, an expression used to denote the curvilinear vacuity of hollow bodies.

Concave *Lenses*, or *Mirrors*, have either one or both sides concave. *See* Lens and Mirror.

CONCAVITY, from concave, the hollow or vacuity of bodies.

CONCAVO-Concave *Lens*, is that which is concave on both sides. Concavo-*Convex Lens*, is that which is concave on one side, and convex on the other.

CONCENTRATION, the bringing things nearer to a centre: whence the particles of salt water are said to be concentrated by evaporating the watery part.

Concentration, in Chemistry, the act of increasing the strength of fluids, which are rendered stronger by abstracting a portion of the mere menstruum. This is generally effected by evaporation, where the menstruum is driven off at a lower heat than is required to drive off the substance with which it is united.

CONCENTRIC, having a common centre, as concentric circles, ellipses, &c.

CONCESSION, in Rhetoric, a figure by which something is allowed that yet might be disputed, in order to obtain another point.

CONCHOLOGY. The study of shells, or testaceous animals, is a branch of natural history, though not greatly useful in human economy, yet by the beauties of the subjects of which it treats, is adapted to recreate the senses, and insensibly lead to the contemplation of the glory of the Divinity in their creation. The term conchology comprehends the study of all animals which have a testaceous covering, whether inhabitants of the marine element, fresh water, or the land. Testaceology is a term synonymous with conchology, but is of later origin and application.

CONCLAVE, the place in which the cardinals of the Romish church meet and are shut up, in order to the election of a pope. The conclave is a range of small cells, ten feet square, made of wainscot: these are numbered, and drawn for by lot. They stand in a line along the galleries and hall of the Vatican, with a small space between each. Every cell has the arms of the cardinal over it. The conclave is not fixed to any one determinate place, for the constitutions of the church allow the cardinals to make choice of such a place for the conclave as they think most convenient; yet it is generally held in the Vatican. The conclave is very strictly guarded by troops; neither the cardinals, nor any person shut up in the conclave, are spoken to but at the hours allowed of, and then in Italian or Latin; even the provisions for the conclave are examined, that no letters be conveyed by that means from the ministers of foreign powers, or other persons who may have an interest in the election of the pontiff.

CONCOCTION, in Anatomy, &c. may be defined the action of fitting our daily aliment for the support and nourishment of our bodies; and also the description of all that disposition of parts and mechanism of system which unite in effecting that change in our food by which it is converted into blood, chyle, &c. To have a clear idea of the manner in which concoction is performed, we must distinguish it into three stages: the first is performed in the progress of the aliment from the mouth down to the lacteals; which are vessels that receive the chyle from the intestines; the second is performed in the passage of the milky liquor called chyle, through the lacteal vessels to the loins, and then up under the collar bone, where it mingles with the blood; the third, or ultimate stage of concoction, is performed by the circulation of the blood and chyle together through the lungs, and the whole arterial system. In all these stages, the design seems evidently to have been to grind and dissolve the aliment, and to incorporate it with a large quantity of animal juices already prepared, and reduce it at last to the very same substance with our blood and humours.

In the first stage of concoction, by a curious configuration of parts, and action of muscles, adapted to their respective functions, our food is ground small by the teeth, and moistened by a copious saliva in the mouth. It is in the next place swallowed, and conveyed down the gullet, where it is farther mollified and lubricated by a viscid unctuous humour, distilled from the glands of that canal. From thence it slips into the stomach, where several causes concur towards its complete dissolution. It is diluted by the juices, swelled and subtilized by the internal air, and it is macerated and dissolved by the heat which it meets with in the cavity. It is also agitated and attenuated by the perpetual friction of the coats of the stomach, and the pulsation of the arteries there; by the alternate elevation and depression of the diaphragm or midriff in breathing; and by the compression of the strong muscles of the belly. After a proper stay, it is gradually propelled into the intestines, in the form of a thick, smooth, uniform, ash-coloured fluid.

When our aliment, thus prepared, arrives at the intestines, it is there mixed with three different sorts of liquors. It receives two kinds of bile; the one, thick, yellow, and extremely bitter, from the gall-bladder; the other, scarcely bitter, or yellow, but in a much larger quantity, from the liver. The third liquor that falls here upon the food, issues plentifully from a large glandular substance, called the pancreas or sweet-bread, and is a limpid mild fluid, like the saliva, which serves to dilute and sweeten what may be too thick and acrimonious. The two saponaceous biles resolve and attenuate viscid substances; incorporate oily fluids with aqueous ones, making the whole mixture homogeneous; and by their penetrating and detergent qualities render the chyle fit to enter the lacteal veins, into which it is conveyed, partly by their absorbent nature, and partly by the peristaltic motion of the intestines.

If we now consider the change which our aliment has undergone, in the mouth, gullet, and stomach, together with a large quantity of bile, and pancreatic juice poured upon it in the intestines; and if we reflect also on the incessant action of the muscles, blending, churning, and incorporating the whole, we shall readily perceive, that their united agency must alter the flavours and properties of the different kinds of food, in such a manner as to bring the chyle nearer in its nature to our animal juices, than to the original substances from which it was formed. Our food, thus changed into chyle, constitutes the first stage of concoction; and we shall find the same assimilation carried on through the second.

The next stage begins with the slender lacteal veins, where they arise from the intestines by an innumerable multitude of invisible pores, through which the fine, white, fluid part of the chyle is strained or absorbed; while, at the same time, the gross, yellow, fibrous part, conveyed slowly forward, and further attenuated in the long intestinal tube, is perpetually pressed and drained of its remaining chyle, until the dregs, becoming at last useless, are ejected out of the body. These lacteal veins issue from the intestines in various directions, sometimes straight, and then oblique, often uniting and growing larger, but presently separating again. They frequently meet at acute angles, and enter into soft glands dispersed through the mesentery, from which they proceed larger than before, and more turgid, with a fine lymphatic fluid: in most places also they run contiguous to the mesenteric arteries, by whose pulsation their load is pushed forward. And thus, after various communications, separations, and protrusions, the lacteal veins pour their chyle into a sort of cistern or reservoir formed for that purpose, between the lowest portion of the diaphragm and highest vertebre of the loins. It is very remarkable, that these veins are furnished with proper valves, which permit the chyle to move forward, but effectually stop its return; and that a great number of veins purely lymphatic, as well as the lacteal ones, empty themselves into the same cistern.

In all this contrivance it is evident, that the chyle, being more and more diluted and blended with abundance of lymph from the glands through which it passes, and from other sources, approaches still nearer to the nature of our animal juices, and consequently becomes more fit for nutrition.

The chyle is pushed from its reservoir into a narrow transparent pipe, called the thoracic duct, which climbs in a perpendicular direction by the side of the back-bone, from the loins up to the collar-bone, and opens into the subclavian vein: where, by the peculiar arrangement of several small valves, the chyle mingles gently with the blood after it has been thoroughly elaborated, and attenuated with lymph from every part of the thorax, or great cavity of the breast, and is from thence soon conveyed to the heart.

Thus we may perceive, that by a wonderful mechanism, a large quantity of chyle and lymph is forced upwards, in a perpendicular course, through a thin slender pipe; but to render this more plain, the following particulars must be attended to:—First, to the progress of the chyle, urged forward and continued from the antecedent action of the intestines, and the beating of the mesenteric arteries. Secondly, to the motion of the diaphragm and lungs, in respiration, pressing the thoracic duct that lies under them, whilst the thorax, rising and falling, resists their action, whereby the duct is squeezed between two contrary forces, and the liquor which it contains pushed upwards. Thirdly, this duct runs close by the side of the great artery, (called by anatomists, the superior portion of the descending aorta,) whose strong pulsation presses its yielding sides, and compels the chyle and lymph to mount in an upright ascent. Fourthly, it must be observed, that this duct is accommodated with valves, which permit its contents to move upwards by every compression, but never to fall back again. Thus terminates the second stage of concoction, when the chyle falls into the heart. And it may be seen, that in the progress through these two stages, our aliment has been mixed accurately with all the substances or principles which compose the blood, *viz.* saliva, mucus, lymph, bile, water, salts, oil, and spirits. The most fluid and subtile parts of our aliment, before and after it is elaborated into chyle, pass into the blood by certain absorbent veins dispersed all over the mouth, gullet, stomach, and intestines: when we consider how quickly refreshments and strength are communicated to weary, faint, and hungry people, immediately upon drinking a glass of good wine, or eating any cordial spoon-meat, this remark will appear the more obvious.

The third stage begins where the chyle mingles with the blood, and falling soon into the right ventricle of the heart, is from thence propelled into the lungs. It will appear that the lungs are the principal instruments of converting the chyle into the blood; especially if we consider their structure, first with regard to the air-vessels of which they are composed, and secondly, with regard to their blood-vessels; for we shall then clearly perceive the change which their fabric and action must produce on the chyle.

The windpipe is composed of segments of cartilaginous rings on the fore part, to give a free passage to the air in respiration; and of a strong membrane on its back part, to bend with the neck, and give way to the gullet in deglutition. This pipe is lined throughout with an infinity of glands, which perpetually distil an unctuous dense humour to lubricate and anoint the passages of the air. Soon after the windpipe has descended into the cavity of the breast, it is divided into two great branches; and these two are subdivided into innumerable ramifications called bronchia, which become smaller in their progress, (not much unlike a bushy tree inverted,) until at last they terminate in millions of little bladders which hang in clusters at their extremities, and are inflated by their admission of air, and subside at its expulsion. The clusters constitute the lobes of the lungs.

The blood-vessels of the lungs next deserve our attention. The branches of the pulmonary artery run along with those of the windpipe, and are ultimately subdivided into an endless number of capillary ramifications, which are spread like a fine net-work over the surface of every individual air-bladder; and the pulmonary vein, whose extreme branches receive the blood and chyle from those of the arteries, run likewise in form of a net over all the air-bladders of the bronchia.

From this admirable structure of the lungs, it is obvious, that the crude mixture of the blood and chyle, passing through the minute ramifications of the pulmonary artery and vein, is compressed and ground by two contrary forces, *viz.* by that of the heart, driving the mixture forward against the sides of the bronchia and air-bladders; and by the elastic force of the air equally repelling this mixture from the contrary side. By these two opposite forces, the chyle and blood are more intimately blended and incorporated; and by the admission and expulsion of the air in respiration, the vessels are alternately inflated and compressed, (and probably some subtile air or æther is received into the blood,) by which means the mixture is still farther attenuated and dissolved; and after various circulations through the lungs and heart, and the whole arterial system, is at last perfectly assimilated with the blood, being fitted to nourish the body, and answer the different purposes of animal life.

When the blood, thus prepared from the aliment, is, by repeated circulations, gradually drained of all its bland and useful parts, and begins to acquire too great a degree of acrimony, it is carried off by both sensible and insensible evacuations, through the several channels and distributions of nature. By these evacuations the body is made languid, and requires a fresh supply of aliment; while at the same time the saliva, and juices of the stomach and intestines, becoming thin and acid by multiplied circulations, vellicate the nerves of those passages, and excite hunger, as a faithful monitor, to remind us of that refreshment which is now become necessary.

CONCORD, in Grammar, is the same with syntax, in which the words of a sentence perfectly agree: that is, in which nouns are in the same gender, number, and case; and verbs in the same number and person with nouns and pronouns.

Concord, in Music, is the union of sounds, and is either perfect or imperfect; perfect concords consist of the fifth and eighth, the imperfect of the third and sixth.

CONCORDANCE. This word has been applied appropriately to a sort of dictionary of the Bible, explaining the words thereof in alphabetical order, with the several books, chapters, and verses quoted in which they are contained. Its chief use is to enable a person to find out any text of scripture, of which he is able to recollect any of the chief words.

CONCORDAT, a covenant or agreement with the pope concerning the acquisition, permutation, and resignation of ecclesiastical benefices. Most Catholic sovereigns have such a treaty with the pope.

CONCRETE Numbers, are those which are made to denote any particular thing, as three pounds, three guineas, &c. and are thus distinguished from abstract numbers, which have reference to no particular subject or thing, as 3, 4, &c.

CONCRETIONS, Morbid, hard substances in different parts of the animal body.

CONDENSATION, the act whereby a body is rendered more dense, compact, and heavy. Condensation is, by most writers, distinguished from compression, by considering the latter as performed by some external violence; whereas the former is the action of cold.

CONDENSER, a pneumatic engine, or syringe, whereby an uncommon quantity of air may be condensed into a given space; so that sometimes ten atmospheres, or ten times as much air as there is at the same time, in the same space, without the engine, may be thrown in by means of it, and its egress prevented by valves properly disposed. It consists of a brass cylinder, wherein is a moveable piston; which being drawn out, the air rushes into the cylinder through a hole provided on purpose; and when the piston is again forced into the cylinder, the air is driven into the receiver through an orifice, furnished with a valve to prevent its escape. *See* Air Gun.

CONDIMENTS. These are not properly alimentary matters, or such as become ingredients in the composition of the animal fluid; yet they are taken with advantage along with the proper aliments, the digestion and assimilation of which they, in some degree, modify. They are of two kinds, saline or acrid; having this acrimony, for the most part, residing in their oily parts. To this list of condiments, we may add capsicum, ketchup, and soy, observing, that the whole of the seasonings consist of salt, vinegar, and aromatics, combined together; and if they are taken only in the quantity necessary to render the food more sapid, they may increase the appetite, and favour full eating; but they can hardly otherwise do harm, unless when the aromatics are taken in such large quantity as to weaken the tone of the stomach.

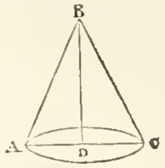
CONDITION, in Civil Law, a clause of obligation, stipulated as an article of a treaty or contract, legacy, &c. In the Common Law, condition is a restraint annexed to any thing, so that by the nonperformance the party shall sustain loss, and by the performance receive advantage.

CONDUCTOR, any body which receives and communicates the electric fluid.

Conductor, in Electricity, a term first introduced into this science by Dr. Desaguliers, and used to denote those substances which are capable of receiving and transmitting electricity; in opposition to electrics, in which the matter or virtue of electricity may be excited and accumulated, or retained. The former are also called non-electrics, and the latter non-conductors. And all bodies are ranked under one or other of these two classes, though none of them are perfect electrics, nor perfect conductors, so as wholly to retain, or freely and without resistance to transmit, the electric fluid. To the class of conductors belong all metals and semimetals, ores, and all fluids, (except air and oils,) together with the substances containing them, the effluvia of flaming bodies, ice, (unless very hard frozen) and snow, most saline and stony substances, charcoals, of which the best are those that have been exposed to the greatest heat; smoke, and the vapour of hot water. It seems probable, that the electric fluid passes through the substance, and not merely over the surfaces of metallic conductors; because, if a wire of any kind of metal be covered with some electric substance, as resin, sealing-wax, &c. and a jar be discharged through it, the charge will be conducted as well as without the electric coating. It has also been alleged, that electricity will pervade a vacuum, and be transmitted through it almost as freely as through the substance of the best conductor; but the electric spark or shock would no more pass through a perfect vacuum than through a stick of solid glass. In other instances, however, when the vacuum has been made with all possible care, the experiment has not succeeded. It has also been observed, that many of the forementioned substances are capable of being electrified, and that their conducting power may be destroyed and recovered by different processes: for example, green wood is a conductor; but baked, it becomes a non-conductor; again, its conducting power is restored by charring it; and lastly, it is destroyed by reducing this to ashes. Again, many electric substances, as glass, resin, air, &c. become conductors by being made very hot; however, air heated by glass must be excepted.

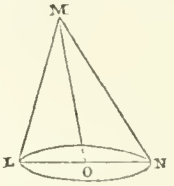
Conductor, *Prime*, is an isolated conductor, so connected with the electrical machine, as to receive the electricity immediately from the excited electric.

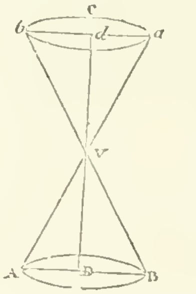
Conductors of *Lightning*, are pointed metallic rods fixed to the upper parts of buildings, to secure them from strokes of lightning. These were invented and proposed by Dr. Franklin for this purpose, soon after the identity of electricity and lightning was ascertained; and they exhibit a very important and useful application of modern discoveries in this science. This ingenious philosopher having found that pointed bodies are better fitted for receiving and throwing off the electric fire than such as are terminated by blunt ends or flat surfaces, and that metals are the readiest and best conductors, soon discovered that lightning and electricity resembled each other in this and other distinguishing properties; he therefore recommended a pointed metalline rod, to be raised some feet above the highest part of a building, and to be continued down into the ground, or the nearest water. The lightning, should it ever come within a certain distance of this rod or wire, would be attracted by it, and pass through it in preference to any other part of the building, and be conveyed into the earth or water, and there dissipated, without doing any damage to the building. Many facts have occurred to evince the utility of this simple and seemingly trifling apparatus. And yet some electricians have objected to the pointed termination of this conductor, preferring rather a blunt end; because they conceive a point invites the electricity from the clouds, and attracts it at a greater distance than a blunt conductor.



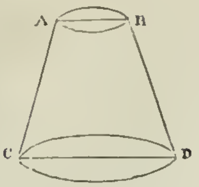
CONE, is a solid body having a circular base, and its other extremity terminated in a single point or vertex. Cones are either *right* or *oblique*. A *Right* Cone, is that in which the right line joining the vertex and centre of the base, is perpendicular to the plane of the base; as A B C. A right cone may be conceived to be generated by the revolution of the right-angled triangle B D C, about its perpendicular B D. And thus, Euclid defines a cone to be a solid figure, whose base is a circle, and is produced by the entire revolution of the plane of a right-angled triangle about its perpendicular, being called the axis of the cone. Right cones are distinguished into classes, according to the magnitude of the angle at the vertex, made by a plane passing through that point perpendicular to the base. An *Acute-angled* Cone, is that in which the angle A B C is acute, or less than a right angle. An *Equilateral* Cone has its side A B equal to the diameter of the base A C. An *Obtuse-angled* Cone, is that in which the angle A B C is obtuse, or greater than a right angle. A *Right-angled* Cone, is that in which the angle A B C is a right angle.

An *Oblique* Cone, is that in which the line joining the vertex and centre of the base is not perpendicular, but oblique, to the plane of the base; as L M N This solid, which is not treated of by the ancient geometricians, is evidently not included in the preceding definition, that having reference to the right cone only. It has therefore been an object with the moderns to render the above more general, so as to include both cases under one and the same general definition or description, which is as follows:—If a line V A continually pass through the point V, turning upon that point as a joint, and the lower part of it be carried round the circumference A B C of a circle; then the space enclosed between that circle and the path of the line is a cone. The circle A B C is the base of the cone, V the vertex, and the line V D the axis; D being the centre of the circle.





Properties of the Cone.—1. Every cone, whether right or oblique, is equal to one-third of a cylinder of equal base and altitude. And therefore the solidity of a cone is found by multiplying the area of its base by one-third of its perpendicular altitude. 2. The curve surface of a right cone is equal to a circular sector, having its radius equal to the slant height of the cone, and its area equal to the whole circumference of the cone's base. And therefore this surface is equal to half the product of the slant side into the circumference of the base. 3. The surface of an oblique cone is not quadrable; indeed no rule has yet been found that will even lead to a practical approximation of its area, notwithstanding the attempts of several ingenious and able mathematicians. 4. The solidity of a cone with an elliptic base, forming part of a right cone, is equal to the product of its surface by a third of one of the perpendiculars, drawn from the point in which the axis of the right cone intersects the ellipse; and it is also equal to one-third of the height of the cone multiplied by the area of the elliptic base. Consequently, the above perpendicular is to the height of the cone, as the elliptic base is to the curve surface. See Dr. Barrow's "Lectiones Geometricæ."



Frustum of a CONE, is that which is formed by cutting off the upper part of a cone,* by a plane parallel to its base; as the figure A B C D.

CONES of the *higher kinds*, are those whose bases are circles of the higher kinds; and are generated by supposing a right line fixed in a point above, though conceived capable of being extended more or less, on occasion; and moved or carried round a circle.

CONE of *Rays*, in Optics, includes all the several rays which fall from any point of a radiant, on the surface of a glass.

CONE, or *Spindle* (*Double*), in Mechanics, is a solid formed of two equal cones joined at their bases. If this be laid on the lower part of two rulers, making an angle with each other, and elevated in a certain degree above the horizontal plane, the cones will roll upwards towards the raised ends, and seem to ascend, though in reality the centre of gravity is descending lower.

CONFESSION of an offence, is when a prisoner is arraigned, and his indictment being read, either he confesses the offence, or pleads not guilty. Confession is express or implied. Express, is where one, in open court, confesses the crime, in the most satisfactory ground of conviction. Implied, is where the defendant, in a case not capital, yields to the king's mercy, and desires to submit to a small fine, which the court may accept, without requiring a direct confession. The presumption of guilt in this case is so strong, that the defendant cannot afterwards, in a civil action, deny the trespass. Confession, previous to trial, before a justice, &c. may also be given in evidence afterwards, as against the individual confessing; but it must be voluntary, not upon promise or threats, and must be taken in time. After confession, the party may take advantage of errors in the indictment, in arrest of judgment. Confession may also be, in a civil action, and is commonly on a warrant of attorney for that purpose, which being after accompanied with a bond, is vulgarly called a bond and judgment.

CONFIGURATION, the exterior surface or shape that bounds bodies, and gives them their particular figure.

CONFISCATE, from *confiscare*, and that from *fiscus*, the emperor's treasure. Any goods which being disclaimed by another, as a felon upon trial, comes to the king, although they are the felon's own. Those which he claims as his own, are, upon conviction, not confiscate, but forfeited to the king.

CONFLUENT, in Medicine, an appellation given to the kind of small-pox, wherein the pustules run into each other.

CONFORMATION, that make and construction of the human body peculiar to every individual; whence those diseases called organical, depend upon the mal-conformation of the parts.

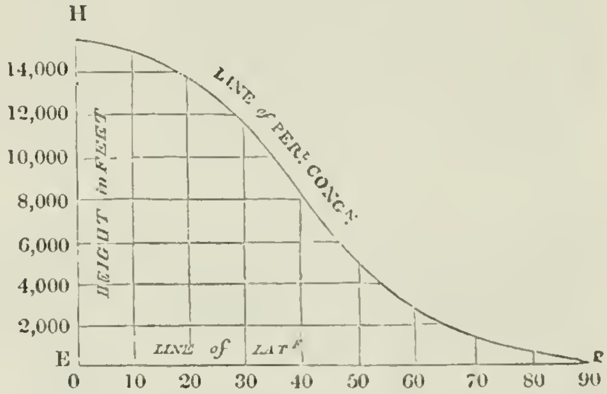
CONGE D'ELIRE, in ecclesiastical polity, the king's permission granted, under his signature, to a dean and chapter to elect a bishop.

CONGELATION, the transition of a liquid into a solid state, in consequence of an abstraction of heat: thus metals, oil, water, &c. are said to congeal when they pass from a fluid into a solid state. With regard to fluids, congelation and freezing mean the same thing. Water congeals at 32°; and there are few liquids that will not congeal, if the temperature be brought sufficiently low. Every particular kind of substance requires a different degree of temperature for its congelation, which affords an obvious reason why particular substances remain always fluid, while others remain always solid, in the common temperature of the atmosphere; and why others are sometimes fluid, and at others solid, according to the vicissitudes of the seasons, and the variety of climates.

In consequence of the diminution of temperature, which is experienced as we ascend in the atmosphere, it is evident, that in every climate a point of elevation may be reached where it will be continually freezing. The altitude of the point above the surface of the earth, will depend partly on the temperature of the lower regions of the atmosphere, and partly on the decrement of heat belonging to the column at the period of observation. Thus, near the equator, it was observed by Bouguer, that it began to freeze on the sides of the lofty mountain Pinchencha, at the height of 13,577 feet above the level of the sea, whereas congelation was found by Saussure to take place on the Alps at the height of 13,428 feet. By tracing a line on the plane of the meridian, through the points at which it constantly freezes, a curve is obtained, which has been denominated the line of *Perpetual Congelation.* The height at which this curve intersects a vertical line in the various latitudes, has been computed by Kirwan, partly from observation, and partly from the mean temperature of the parallel, and the decrement of heat, as we ascend in the atmosphere. The following table exhibits the result of his calculation; and though it is constructed on the erroneous supposition, that the mean annual temperature of the pole is 31°, which, according to the observations of Captain Scoresby and Captain Parry, must be far beyond the truth, it is tolerably accurate for the more accessible regions of the globe.

Latitude.	Mean Height of Line of Congelation.	Latitude.	Mean Height of Line of Congelation.
·0	15·577	45	7·658
·5	15·457	50	6·260
10	15·067	55	4 912
15	15·498	60	3·684
20	13·719	65	2·516
25	13·030	70	1·557
30	11·592	75	·718
35	10·664	80	·128
40	9·016		

These numerical relations will be best perceived at a glance by means of the following diagram.



Here E P represents the rectified meridian from the equator to the pole divided into intervals of 10° each; and the different perpendiculars or ordinates at the point 0, 10, 20, &c. represent the height of the *freezing point* at the equator, and at latitude 10, 20, &c. to the pole P. The curve H P, which has a contrary flexure about 60°, exhibits the general form of the line of Perpetual Congelation from the equator to the pole.

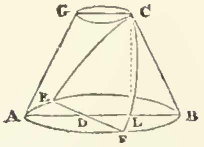
CONGRUITY, in Geometry, is the same as identity, those lines and surface being congruous, which will coincide or fill the same space.

CONGRUOUS QUANTITIES, are those which are of the same kind, and therefore admit of comparison; and quantities which cannot be so compared, are incongruous quantities. All abstract numbers are congruous; but concrete numbers are not congruous, unless the quantities they represent be so. Thus, 3 and 4, as abstract numbers, are congruous; but if they denote 3 pounds and 4 miles, they are incongruous. Hence it follows, that the method commonly given in books of arithmetic, for stating questions in the Rule of Three, is improper; because it supposes a comparison between quantities which are incongruous. We cannot say properly, that 3 pounds : 4 men : : 6 pounds : 8 men; but that 3 pounds : 6 pounds : : 4 men : 8 men.

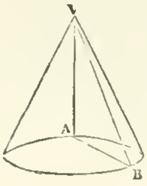
CONICAL, any thing of a conical form, or relating to the cone.

CONICAL *Ellipse*, *Hyperbola*, *Parabola*, denote those figures, under their most simple form, as cut from the cone, to distinguish them from the same figures of a higher order. See the respective articles.

Conical *Ungula*, or Conic *Ungula*, is a solid formed by a plane passing through the side and base of a cone, as the figure E C B F, fig. 1.

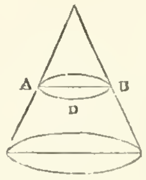


Conic *Sections*, as the name implies, are such curve lines and plane figures as are produced by the intersection of a plane with a cone. From the different positions of the cutting plane, there arise five different sections, *viz.* a *triangle*, *ellipse*, *parabola*, and *hyperbola*. But only the three latter are particularly denominated *conic sections*. 1. If the secant, or cutting plane, pass through the vertex of the cone, and any part of the base, the section will evidently be a *triangle*, as A V B, fig. 2.



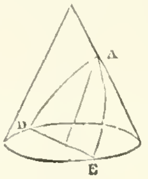
2. If the plane cut the cone parallel to the circular base, the section will be a *circle*, as A B D.

3. If the plane pass through the side and base of the cone parallel to the other side; that is, if the cutting plane make the same angle with the base as the side of the cone makes, the section is a *parabola*, as D A B, fig. 3.

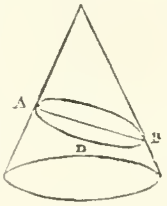


4. When the plane cuts both sides of the cone, that is, when it makes with the base a less angle than the side of the cone makes, the section is an ellipse, as B A D.

5. When the plane passes through the side and base of the cone, making a greater angle with the base than the side or the cone makes, the section is an *hyperbola*, as D A E, fig. 4.



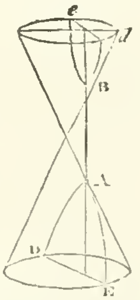
And if the plane be continued to cut the opposite cone, this section is called the opposite *hyperbola* to the former, as B *e d*, fig. 6.



6. The *vertices* of any section are the points where the cutting plane meets the opposite sides of the cone, as A and B in the preceding figures. Hence the ellipse, fig. 5, and hyperbola fig. 4, have each two vertices, but the parabola only one, unless we consider the other as at an infinite distance.

7. The *axis*, or *transverse diameter*, of a conic section, is the line joining its vertices, as A B; therefore the axis of an ellipse is within the figure, of the hyperbola without it, and in the parabola it is infinite in length, fig. 6.

8. The *centre* of a conic section is in that point which bisects the axis. Hence the centre of an ellipse is within the figure, of the hyperbola without the figure, and in the parabola it is at an infinite distance from the vertex.



The definition of the other lines, in and about the conic sections, will be found under their respective heads; and the principal properties of the different sections, under the articles Ellipse, Hyperbola, and Parabola.

The conic sections are of themselves a system of regular curves allied to each other, the doctrine of which is of the greatest use in physical astronomy, as well as in the physico-mathematical sciences, and has been much cultivated by both ancient and modern mathematicians.

CONIUM. Hemlock, a genus of the digynia order, in the pentandria class of plants, and in the natural method belonging to the 45th order, umbellatæ. There are five species. Conium maculatum, or the greater hemlock, grows naturally in Britain. It is a biennial plant. The stalk is smooth, spotted with purple, and rises from four to six feet, branching out at the top with decompounded leaves. The flowers are white. It is a poisonous plant, yet the internal and external efficacy of the hemlock has been proved in cancers, ulcers, and scrofulous tumors.

CONJUGATE Diameter, or Axis of an Ellipsis, is the shortest of the two diameters, or that which bisects the transverse axis.

CONJUGATION, in Grammar, a regular distribution of the inflexions of verbs in their different voices, moods, tenses, numbers, and persons, to distinguish them from each other.

CONJUNCTION, in Astronomy, the meeting of two or more stars or planets in the same degree of the zodiac.

Conjunction may be considered as either *true* or *apparent*. When the two bodies meet in the same point of both longitude and latitude, the conjunction is *true;* when they agree in longitude, but differ in latitude, the conjunction is *apparent*.

Conjunction is either *heliocentric* or *geocentric.—Heliocentric* conjunction is that which would appear to an observer at the sun; *geocentric*, that which would appear to one upon the earth.—*Geocentric* Conjunctions are either *superior* or *inferior:* thus, when a planet is seen on the same circle of latitude with the sun, but beyond him, the conjunction is called *superior;* when the planet is seen between the earth and sun, the conjunction is *inferior.—Grand* Conjunctions, are those wherein several of the planets are seen near together. M. de la Lande informs us, that on May 22, 1702, Jupiter and Saturn were within 1° 4′ of each other; on February 11, 1524, Venus, Mars, Jupiter, and Saturn, were very near each other, and Mercury not above 16° from them; on November 11, 1544, Mercury, Venus, Jupiter, and Saturn, were within the space of 10°; on March 17, 1725, Mercury, Venus, Mars, and Jupiter, were so near each other as to be all seen through the same telescope without altering its position; and on December 23, 1769, Venus, Mars, and Jupiter, were within 1° of each other.—The Chinese have a remarkable record of a conjunction of five planets, which happened in the time of their emperor, Tchuenhiu; who, according to the Chinese annals, reigned from the year 2514, before Christ, to the year 2436, B.C.; and which is thought to prove the great antiquity of this empire, and of astronomical science amongst these people.

Conjunction, in Grammar, an inclinable word or particle, which joins words or sentences together, shewing their mutual relation and dependence.

CONJURATION, strictly means combining together by oath, especially with evil spirits to do a public harm. The using of witchcraft, conjuration, &c. was felony by 1 Jac. c. 12. but that was repealed by 9 Geo. II. c. 5, and the offences and all prosecutions for them abolished; but if any pretend to witchcraft, or conjuration, or to tell fortunes, or from skill in occult or crafty science, to discover goods or chattels supposed, they shall be imprisoned a year, and stand in the pillory once a quarter, and may be ordered to give security for good behaviour. The punishment of the pillory being abolished, they are only liable to the other penalties of the statute.

CONOID, a solid figure generated by the revolution of any conic section about its axis; and hence receives particular denominations, according to the section from which it is produced; as Elliptical *Conoid* or *Spheroid*, Parabolic *Conoid*, and Hyperbolic *Conoid;* for which, see the respective articles.

CONON, an ancient Greek mathematician, the friend of Archimedes. He was well skilled in geometry and astronomy, but is not celebrated for any particular discovery.

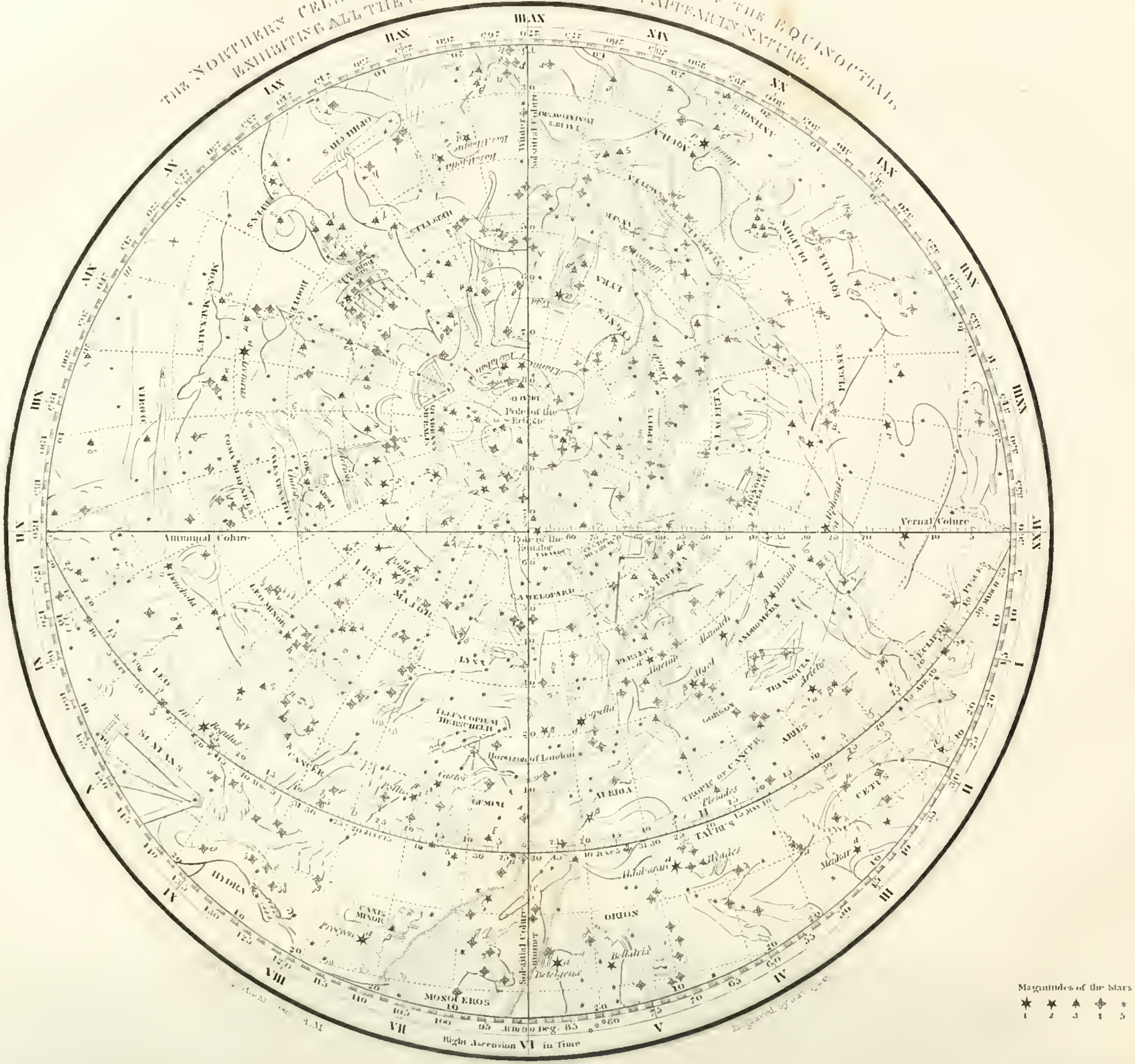
CONSANGUINITY, the relation subsisting between persons of the same blood, or who are sprung from the same root. Consanguinity terminates in the sixth and seventh degree, excepting in the succession of the crown, in which case it is continued to infinity. Marriage is prohibited by the church to the fourth degree of consanguinity inclusive; but, by the law of nature, consanguinity is no obstacle to marriage, except it be in the direct line.

CONSCIENCE, in Ethics, a secret testimony of the soul, whereby it gives its approbation to things that are naturally good, and condemns those that are evil.

CONSCRIPTS, men raised to recruit the French armies. All men capable of bearing arms in France and its dependencies are registered, and when called upon by the government, are obliged to join the army on any service.

CONSEQUENT, is the latter of two terms of a ratio, or that

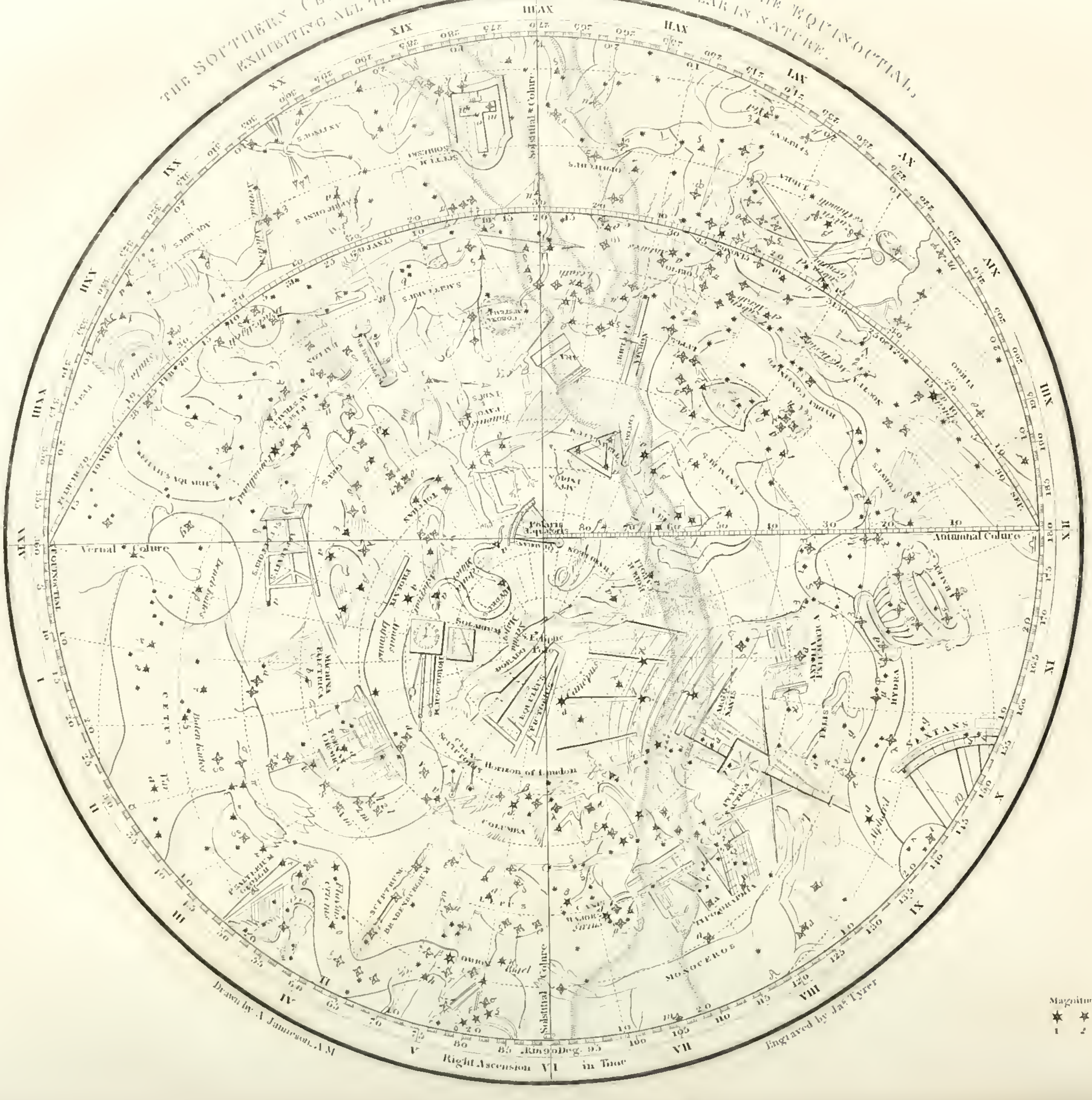
THE NORTHERN CELESTIAL HEMISPHERE ON THE PLANE OF THE EQUINOCTIAL, EXHIBITING ALL THE CONSTELLATIONS, AS THEY APPEAR IN NATURE.



Engraved by [illegible]

Published by Fisher, Son & C. [illegible] London 1826

THE SOUTHERN CELESTIAL HEMISPHERE ON THE PLANE OF THE EQUINOCTIAL, EXHIBITING ALL THE CONSTELLATIONS, AS THEY APPEAR IN NATURE.



Drawn by A. Jameson, A.M.

Engraved by Jas. Tyrer

[illegible]

to which the antecedent is referred and compared; thus in the ratio $a : b$, b is the consequent, and a the antecedent.

CONSEQUENTIA, a Latin term, commonly employed by astronomers to denote the real or apparent motion of a planet or comet, when it is moving from west to east, or according to the order of the signs; and is thus opposed to *antecedendia*, which denotes contrary motion.

CONSIDERATION, in Law, the material cause or ground of a contract, without which the party contracting would not be bound. Consideration, in contracts, is something given in exchange, something that is mutual and reciprocal; as money given for goods sold, work performed for wages. And a consideration of some sort or other is so absolutely necessary to the forming of a contact, that a *nudum pactum*, or agreement to do or pay any thing on one side, without any compensation on the other, is totally void in law; and a man cannot be compelled to perform it. A consideration is necessary to create a debt.

CONSIGNMENT, in Law and Commerce, is the sending or delivering over goods, money, &c. to another person, and is unconditional, or for a particular purpose.

CONSISTENT Bodies, a term partially employed by philosophers, particularly by Boyle, to denote *firm* or *fixed* bodies, in opposition to fluid ones.

CONSISTORY, a tribunal; every archbishop and bishop of every diocese hath a consistory court, held before his chancellor or commissary, in his cathedral church, or other convenient place of his diocese, for ecclesiastical causes. From the bishop's court the appeal is to the archbishop; from the archbishop's court to the delegates.

CONSOLIDATION, in Civil Law, is the uniting the possession or profit of land with the property, and the contrary. It also denotes the uniting two benefices into one.

CONSONANCE, in Music, is the effect of two or more sounds heard at the same time.

CONSONANT, a letter that cannot be sounded without a vowel before or after it. Consonants are divided into single and double; the double are *x* and *z*, the latter are all single; and these are again divided into mutes and liquids, the former are *b, c, d, f, v, g, j, k, p, q, t*, the liquids *l, m, n, r*.

CONSPIRACY, in Law, signifies an agreement between two or more, falsely to indict, or procure to be indicted, an innocent person for felony.

CONSPIRATORS are, by statute, defined to be such as bind themselves by oath, covenant, or other alliance, to assist one another, falsely and maliciously to indict persons, or falsely to maintain pleas.

CONSTABLE, an officer whose duty it is to preserve the peace, and to arrest all public offenders who have committed the offence in his presence, or against whom he has the warrant of a justice of the peace. There are many persons exempted by law from serving the office of constable; these are, the ancient officers of any of the colleges in the two universities, counsellors, attorneys, and all other officers whose attendance is required in the courts of Westminster-hall, aldermen of London, the president and fellows of the fellowship of physic in London, surgeons and apothecaries in London, and within seven miles thereof, being free of the company of apothecaries, and licensed teachers, or preachers in holy orders, in a congregation legally tolerated, shall be exempted from the office of a constable. The prosecutor of a felon to conviction, or the person to whom he shall assign the certificate thereof, shall be discharged from the office of constable. But generally speaking, every housekeeper, inhabitant of the parish, and of full age, is liable to fill the office of constable: he ought, however, to be of the abler sort of parishioners, as being more likely to perform his duty with probity and discretion.

CONSTANT Quantities, in Algebra, are those whose values are known, or which remain constantly the same. These are commonly denoted by the leading letters of the alphabet, *a, b, c*, &c. to distinguish them from the variable and unknown quantities, which are represented by the final letters, *z, y, x*, &c.

CONSTELLATION, in Astronomy, an assemblage or system of several stars, expressed and represented under the name and figure of some animal or other emblem. The ancients portioned out the firmament into several parts or constellations; reducing a certain number of stars under the representations of certain images, in order to aid the imagination and the memory, to conceive and retain their number and disposition, and even to distinguish the virtues which astrologers attributed to them; in which sense a man is said to be born under a happy constellation, *i.e.* under a happy configuration of the heavenly bodies.

The division of the heavens into constellations is probably as old as astronomy itself; at least it was known to the most ancient authors extant, whether sacred or profane. Job, chap. ix. ver. 9, "Which maketh Arcturus, Orion, and the Pleiades, and the chambers of the south." By the "chambers of the south," some have understood the constellations near the south pole, which are invisible to the inhabitants of the northern hemisphere. From the manner in which Job speaks of commerce, we may infer, that he lived in a country frequented by merchants, who imported thither the rarities of the south. Job, who lived in Arabia Petræa, among the merchants, might have derived from them his knowledge of the constellations. Chap. xxxviii. 31, 32, "Canst thou restrain the sweet influence of the Pleiades, or loosen the bands of Orion? Canst thou bring forth Mazzaroth, (by which some understand the twelve signs of the zodiac,) or canst thou guide Arcturus with his sons?" In the prophecy of Amos, who lived 790 years before Christ, we have the following exhortation, (chap. v. 7, 8:) "Ye who turn judgment into wormwood, and leave off righteousness in the earth; seek him that maketh the seven stars and Orion, and turneth the shadow of death into the morning, and maketh the day dark with night; that called for the waters of the sea, and poureth them out upon the face of the earth: the Lord is his name." In this passage, the seven stars and Orion are mentioned as being well known, both by Amos, who was a herdsman of Tekoa, and the common people, to whom this exhortation was addressed; and we may hence infer, that the constellations had been invented for some time before that period. Some of the constellations are also occasionally mentioned by Hesiod and Homer, who flourished above 900 years before Christ; and Aratus of Tarsus, the astronomical poet, who lived about 277 years before Christ, in his "Phenomena," professedly treats of them all, except some few, which were invented after his time; shewing how each constellation is situated with regard to those that are near it, what position it bears with respect to the principal circles of the sphere, and what other constellations rise or set with it. *See* Zodiac.

CONSTITUTION, an ordinance, regulation, or law made by authority of any superior, ecclesiastical or civil.

CONSTITUTION, physically, is that particular disposition of the body, which results from the properties and mutual actions of the solids and fluids enabling them to exercise their proper functions.

CONSTITUTIONS, Apostolical, a collection of regulations attributed to the apostles, and supposed to have been collected by St. Clement, whose name they likewise bear. It is the general opinion, however, that they are spurious, and that St. Clement had no hand in them. They appeared first in the fourth age, but have been much changed and corrupted since that time.

CONSTRUCTION, in Geometry, is the drawing those lines of a figure which are previously necessary for the making a demonstration more plain and evident.

CONSTRUCTION of Equations, in Algebra, is the finding the roots of an unknown equation by the geometrical constructing of right lines or curves; or the reducing given equations into geometrical figure. And this is done by lines or curves, according to the order or rank of the equation.

CONSUL, is an officer established by virtue of a commission from the king, and other princes, in all foreign countries of any considerable trade, to facilitate and despatch business, and protect the merchants of the nation. The consuls are to keep up a correspondence with the ministers of England residing in the courts whereon their consulate depends. They are to support the commerce and the interest of the nation; to dispose of the sums given, and the presents made to the lords and principals of places, to obtain their protection, and prevent the insults of the natives on merchants of the nation.

CONTACT, in Mathematics, is when one line, plane, or body, is made to touch another, and the parts which thus touch are called the points of contact.

CONTAGION, in Physic, the communicating a disease from one body to another. In some diseases it is only effected by an immediate contact, as in the syphilis; in others, it is conveyed by infected clothes; and in others it seems capable of being transmitted through the air at a considerable distance.

CONTENT, in Geometry, is the area or quantity of matter or space included within certain limits.

CONTIGUOUS ANGLES, in Geometry, are those which have one leg common to each angle.

CONTINGENT, something casual or uncertain. Hence, future contingent, in logic, denotes a conditional event which may or may not happen, according to circumstances. *Contingent* is also a term of relation for the quota which falls to any person upon a division. *Contingent use*, in law, is that which is limited in a conveyance of lands, which may or may not happen to vest according to the contingency mentioned in the limitation of the use. A *Contingent remainder* is where no present interest passes; but the estate is limited to take effect, either to a dubious and uncertain person, or upon a dubious and uncertain event, so that the remainder may never take effect.

CONTINUED PROPORTION, in Arithmetic, is that where the consequent of the first ratio is the same with the antecedent of the second.

CONTRABAND, in Commerce, a prohibited commodity, or merchandise bought or sold, imported or exported, in prejudice to the laws and ordinances of a state, or the public prohibitions of the sovereign. Contraband goods are not only liable to confiscation themselves, but also subject all other allowed merchandise found with them in the same box bale, or parcel, together with the horses, waggons, &c. which conduct them. There are contraband goods likewise, which, besides the forfeiture of the articles, are attended with several penalties and disabilities.

CONTRACT, a covenant or agreement between two or more persons with a just consideration. Contracts are either express or implied. Express contracts are, where the terms are openly and plainly uttered; implied, are those dictated by reason and justice: thus, if a man takes up goods without agreeing about the price, the law concludes, that he contracted to pay the real value.

CONTRACTION, or DILATATION, an essential property of bodies, is best learned from experiment. We see that the volume of numerous bodies is enlarged or diminished, by the application of a vast force, or else of some delicate measure; fluids may be expanded or condensed; hard substances enlarged or contracted. Thus, if a flaccid bladder be laid within the receiver of an air-pump, it will gradually swell as the exhaustion advances; but on restoring the external pressure, it will again shrink into its former dimensions.

If a tall flask, nearly filled with water, be inverted in a jar of water, and placed likewise under a pneumatic receiver, the air collected near the top of the flask will visibly expand as the operation of pumping proceeds, till it presses down the water, and begins to make its escape from below in the form of rarefied bubbles.

But air is easily compressed, by the opposite action of a syringe. In the vault or chamber of the air-gun, it is often condensed fifty or even eighty times. Nearly the half of that charge may be thrown into the pneumatic blow-pipe, from which, on partially opening the valve, it will again flow for the space of a quarter of an hour.

Other gases are likewise notably contracted or dilated, by the increase or diminution of external pressure. But liquid substances themselves manifest a similar property, though in a much lower degree. If a large glass ball, terminating in a long narrow and open stem, divided into minute spaces corresponding to the millionth parts of the whole capacity, be filled with distilled water, carefully purged of air, and introduced under the receiver of a pneumatic machine; as the exhaustion advances, the water will proportionally expand, and rise near fifty divisions; but, on admitting the atmosphere again to compress the water, it will sink to its former place in the stem. The contraction which the water suffers, at every increase of pressure, exceeds not indeed the 20,000th part of what air would undergo in like circumstances; but it is equally real, and evinces an inherent property. Mercury treated in the same way shews a contraction three times less than water. Alcohol, ether, oils, and the various acids and saline solutions, are all condensed or expanded, though in different degrees, by the change of atmospheric pressure.

If the stem of the instrument now mentioned, were made to screw to the ball at a wide aperture, fragments of solid bodies could be easily introduced, and the vacant space filled up with water; the contraction of this portion of water being deducted from the contraction of the mixture, would give the distinct condensation of the hard materials. In this way, the compressibility of the various stones and metals could be accurately examined.

The contraction and distention produced by external or internal pressure on glass, is quite visible in a thermometer with a large bulb and very long tube. When the mercury stands near the top of the scale, it will immediately rise on reclining the tube, and will continue to flow till the thermometer has been reversed; but the mercury will again retreat, as the instrument is brought back to its vertical position. This experiment proves, that the bulb has its capacity sensibly enlarged by the thrust of the mercurial column. When long bars of wood, iron, or other metals, are laid horizontal on supports, they bend downwards by their own weight, and this depression is increased by augmenting the incumbent pressure. The upper fibres are therefore drawn into a narrower curve than those at the middle of the bar, while the under fibres are extended into a wider convexity: the particles of the former are thus contracted, and those of the latter distended. It is likewise obvious, that in this incurvation, the contraction or dilatation induced will be proportional to the thickness of the bar.

The various kinds of wood are far more compressible than water, and suffer, hence, a very considerable degree of condensation, or being let down to great depths in the ocean. Pieces of oak, ash, or elm, plunged two or three hours in a calm sea, at the enormous depth of a thousand fathoms, and then drawn up, have been found to contain four-fifths of their weight of water, and to acquire such increase of density as indicates a contraction of the wood into about half its previous volume. The specimens which have undergone this singular change, if thrown into a pail of water, will sink like a stone. Hence probably the reason, why barks lost near the shore, are afterwards discovered by their timbers breaking up and floating to the surface; while the ships which founder in the wide ocean, acquiring permanent density from the vast compression they sustain, remain motionless at the bottom, and never rise again to disclose their fate.

But pieces of wood, even of the softer kinds, whether round or square, may be easily squeezed in the direction perpendicular to their fibres, by the action of a common vice. If allowed to stand only a few minutes under that compression, and immediately thrown into water, they will sink to rise no more. If the wood be kept much longer under the vice, it will take a *set*, and become constitutionally denser. Even cork may, by compression, be made to sink in water; but as its texture is nearly uniform, the force must be exerted on all sides. Into a thick and very strong glass cylinder, having a syringe adapted to it, introduce a large cork ball, and inject the air by quick and powerful strokes; the ball will gradually shrivel, till it has contracted even to less than one-third of its bulk; but on allowing the charge of air to escape, the cork will speedily resume its former shape and dimensions. If the condenser be partly filled with water, on which the ball of cork is set to float, it will, under a like compression, though it has a minute portion of the liquid driven into its substance, shrink to nearly the same size as before, and soon fall to the bottom. Hence the success of the common experiment at sea, of letting down, in calm weather, to the depth of twenty or thirty fathoms, an empty corked bottle, and then drawing it up full of water, though the cork still remains in the neck. The water is not in this case forced through the pores of the cork as generally supposed, but the cork itself being condensed by the lateral pressure of the incumbent mass, allows it to enter by the sides, and dislodge the air.

Bodies are also contracted or dilated, from the operation of some internal cause. Thus, dry air is visibly expanded by its union with moisture. If, in a warm room, the inside of a tall flask be wetted by a few drops of water, and the mouth inverted in a basin of water, the contained air, in proportion as it becomes humified, will discharge a copious stream of bubbles. On the other hand, a notable contraction of their joint volume is produced in the absorption of water by sawdust, linen, or bibulous paper. The combination of equal measures of water and alcohol is accompanied by a contraction amounting to the fiftieth part of the whole. A similar effect results from the solution of the sulphate of soda, and other highly soluble salts.

The alliage of different metals often betrays a large contraction. The power of tin to condense copper in the composition of bronze, was even remarked by the ancients, who combined these metals in various proportions, to form their knives, chisels, or hatchets. Equal bulks of tin and copper are found to suffer a contraction amounting to not less than the fifteenth part of their whole volume.

A liquid, in joining any solid substance, commonly occasions a general contraction; but the solid itself may yet by this accession expand with prodigious force. Thus dry peas being rammed into a gun barrel, and their interstices filled with water, will in a short time burst the barrel. In like manner, if wedges of soft dry wood be driven into slits made with a saw in blocks of freestone or marble, and then have water poured upon them, these wedges will quickly swell and rend the rock. Such was the ancient mode of quarrying, before the explosive power of gunpowder came to be introduced. It is still practised in the art of cutting millstones in France, holes being bored at intervals in a line drawn across the block, and wooden plugs driven into them, and then wetted.

Hence if the side of a thin piece of wood be moistened, it will bend backwards, the humidity insinuating itself into the soft parenchymatous matter between the fibres, and therefore enlarging the circle of flexure. The thinner the wood is sliced, the greater will evidently be the incurvation produced by the wetting of its convex surface. The fibres of hair and wool, by the unequal rubbing and moistening of their sides, are made to curl up, and to condense like a clue. On this property seems to be really founded the very important process of milling, fulling, or felting, by which a raw web of woollen cloth is thickened, and its texture rendered firm and compact.

A leathern thong is extended by wetting, so are the filaments of flax and hemp; though a cord is shortened by wet, the diameter of the coil being increased, and the extension of the overlapping fibres curtailed. A sponge dipped in hot water, and drawn more than once along a rope, it will in dry weather occasion, in one hour, a contraction of one-twentieth part of the whole length,—a remarkable property often advantageously employed as a mechanical agent. But the most powerful principle of internal expansion, is the introduction of heat; whose energies vary exceedingly in different substances, but which can always be reduced to calculation, by comparing its effects with the opposite influence of external compression. Thus the same absolute portions of heat communicated to cylinders of one-inch diameter and height, of air, alcohol, water, mercury, and copper, would enable those columns respectively to sustain the weights of 10, 12, 3, and 2 pounds.

A remarkable phenomenon, of considerable importance in manufactures, obtrudes itself on our notice in this article, which is, the hardness that certain bodies acquire in consequence of a sudden contraction, and this is particularly the case with glass and some of the metals. Thus, glass vessels, suddenly cooled after having been formed, are so very brittle, that they hardly bear to be touched with any hard body. The cause of this may be thus explained: when glass in fusion is very suddenly cooled its external parts become solid first, and determine the magnitude of the whole piece, while it still remains fluid within. The internal part, as it cools, is disposed to contract still further, but its contraction is prevented by the resistance of the external parts, which form an arch or vault round it, so that the whole is left in a state of constraint; and as soon as the equilibrium is disturbed in any one part, the whole aggregate is destroyed. Hence it becomes necessary to anneal all glass, by placing it in an oven, where it is left to cool slowly; for, without this precaution, a very slight cause would destroy it. The Bologna jars, sometimes called proofs, are small thick vessels made for the purpose of exhibiting this effect; they are usually destroyed by the impulse of a small and sharp body; for instance, a single grain of sand, dropped into them, and a small body appears to be often more effectual than a larger one; perhaps because the larger one is more liable to strike the glass with an obtuse part of its surface.

Contraction, in Physics, the diminishing the extent or dimensions of a body, or the causing its parts to approach nearer to each other, in which sense it stands opposed to dilatation or expansion. Water and all aqueous fluids are gradually contracted by a diminution of temperature, until they arrive at a certain point, which is about 8° above the freezing point; but below that point they begin to expand, and continue to do so according as the temperature is lowered; and similar effects have been observed with regard to some metals.

CONTRA-HARMONICAL Proportion, in Arithmetic, is that relation of three terms, wherein the difference of the first and second is to that of the second and third as the third is to the first.

CONTRAVALLATION, in the Military Art, is a line formed in the same manner as that of circumvallation, to defend the besiegers against the sallies of the garrison.

Contravallation, or *the Line of Contravallation*, in Fortification, a trench guarded with a parapet, and usually cut round about a place by the besiegers, to secure themselves on that side, and to stop the sallies of the garrison. *See* Fortification.

CONTROLLER, an officer appointed to control or oversee the accounts of other officers, and, on occasion, to certify whether or no things have been controlled or examined. In England, we have several officers of this name—controller of the king's house, controller of the navy, controller of the customs, controller of the mint, &c.

CONTUMACY, in Law, a refusal to appear in court when legally summoned, or the disobedience of the rules and orders of a court having power to punish such an offence. In England, contumacy may be prosecuted to outlawry.

CONVENTICLE, a private assembly or meeting, for the exercise of religion. The word was first attributed as an appellation of reproach to the religious assemblies of Wickliffe, in this nation, in the reign of Edward III. and Richard II., and was afterwards applied to illegal meetings of nonconformists.

CONVENTION, a treaty, contract, or agreement, between two or more parties. Every convention among men, provided it be not contrary to honesty and good manners, produces a natural obligation, and makes the performance a point of conscience. Every convention has either a name and a cause of consideration, or it has none; in the first case, it obliges civilly and naturally, in the latter only naturally.

Convention, is also a name given to an extraordinary assembly of parliament, or the states of the realm, had without the king's writ; as was the convention of estates, who, upon the retreat of James II. came to a conclusion, that he had abdicated the throne, and that the right of succession devolved to King William and Queen Mary; whereupon their assembly expired as a convention, and was converted into a parliament.

CONVERGENT, or Converging, the tendency of different things, variously disposed, to one common point. It is also sometimes used to denote an approximation towards the real value of a thing.

Converging *Lines*, those which tend to a common point.

Converging *Rays*, those which tend to a common focus.

Converging *Series*, those series whose terms continually diminish. *See* Series.

CONVERSE, in Mathematics, commonly signifies the same thing as *reverse*. Thus, one proposition is called the converse of another, when, after a conclusion is drawn from something supposed in the converse proposition, that conclusion is supposed; and then, that which in the other was supposed, is now drawn as a conclusion from it: thus, when two sides of a triangle are equal, the angles under these sides are equal; and, on the converse, if these angles are equal, the two sides are equal.

Converse propositions are not necessarily true, but require a demonstration; and Euclid always demonstrates such as he has occasion for. An instance or two will shew this. If two right-lined figures are so exactly of a size and form (both respecting their sides and angles) that being laid one on the other, their boundary lines do exactly coincide and agree, then no one doubts that these figures are equal. Now try the converse. If two right-lined figures are equal, then if they be laid the one on the other, their boundary lines exactly coincide and agree. It is manifest that this proposition, though the converse of the former, is by no means true. A triangle and a square may have equal areas; but it is impossible the sides of the former can all coincide with those of the latter. Again, if two triangles have their sides respectively equal, their angles will also be respectively equal, by Euc. i. 8. But, if two triangles have their angles respectively equal, it does not follow that the sides will be respectively equal: this may or may not be true, according to circumstances. Converse propositions, therefore, need a proof, notwithstanding this has been termed superfluous and impertinent by Emerson and some others.

CONVERSION of Proportion, is when, of four proportionals, it is inferred that the 1st is to its excess above the 2d, as the 3d to its excess above the 4th.—Conversion, *Centre* of, in *Mechanics*. *See* Centre of *Conversion*.

CONVEX, round or curved, or protuberant outwards, as the outside of a globular body.

CONVEXITY, the exterior or outward surface of a convex or round body.

CONVEXO-Concave Lens, is one that is convex on one side, and concave on the other.—Convexo-*Convex Lens*, is one that is convex on both sides.

CONVEYANCE, in Law, a deed which passes from one or more persons to others.

CONVICT, in Common Law, a person that is found guilty of an offence by the verdict of a jury. The law implies, that there must be a conviction before punishment for any offence, though it be not mentioned in any statute. On a joint indictment, or information, some of the defendants may be convicted, and others acquitted.

Convict *Recusant*, a person who has been legally presented, indicted, and convicted, for refusing to come to church to hear the common prayer, according to the statutes 1 and 23 Eliz. and 3 Jac. I.

CONVOCATION, an assembly of the clergy of England, by their representatives, to consult of ecclesiastical matters. It is held during the session of parliament, and consists of an upper and lower house. In the upper sit the bishops, and in the lower the inferior clergy. The convocation is now a mere form, and never enters upon business.

CONVOLVULUS, *Bind-Weed*, a genus of the pentandria class and monogynia order, in the natural method ranking under the 29th order, campanaceæ, of which there are 110 species.

CONVOY, in Marine affairs, one or more ships of war, employed to accompany and protect merchant ships, and prevent their being insulted by pirates, or the enemies of the state in time of war.

Convoy, in Military matters, a body of men that guard any supply of men, money, ammunition, or provisions, conveyed by land into a town, army, or the like, in time of war.

CONVULSION, a preternatural and violent contraction of the membraneous and muscular parts of the body.

CONUS, in Natural History, a genus of Vermes Testacea, is divided into five distinct families. There are upwards of seventy species enumerated. Many of the conus tribe are beautiful shells, and bear a high price on account of their rarity. We have no species of this genus upon the English coast. Some very curious kinds have been discovered in a fossil state in England, chiefly in the chalk cliffs of Hampshire.

COOKERY, or Cooking, the exercise of art in the preparation of food for human sustenance. It consists not only in the application of heat under various modifications and circumstances, but also in the due intermixture of condiments, calculated as well to please the palate as to promote nutrition. The exercise of this art is peculiar to man, and it has been deemed by naturalists one of his peculiar characteristics, that he is "a cooking animal." Dr. Cullen says, that the cooking of vegetables by boiling, renders them more soluble in the stomach, notwithstanding the degree of coagulation which their juices undergo. In the second place, the application of a boiling heat dissipates the volatile parts of vegetable substances, which are seldom of a nutritious nature, but, in many cases, have a tendency to prove noxious. In the third place, boiling helps to extricate a considerable quantity of air, that, in the natural state of vegetables, is always fixed in their substance; and it is probably in this way, especially, that heat contributes to the dividing and loosening the cohesion of their smaller parts. Thus, they are rendered less liable to ferment, and to produce that flatulence which is so troublesome to weak stomachs.—In the cookery of animal substances, some practices, previous to the application of heat, are to be considered as affecting the solubility in the stomach; particularly salting and pickling. These processes are spoken of under the article Condiments.

The cookery of animal substances is of two kinds, as it is applied in a humid form in boiling and stewing; or in a dry form, in roasting, broiling, and baking. By the joint application of heat and moisture to meat in boiling, the texture is rendered more tender and soluble in the stomach; and it is only in this way that the firmer parts, as the tendinous, ligamentous, and membranous parts, can be duly softened, and their gelatinous substance rendered subservient to nutrition. Yet these effects are different according to the degree of boiling. A moderate boiling may render their texture more tender, without much diminution of their nutritious quality; but if the boiling is extended to extract every thing soluble, the substance remaining is certainly less soluble in the stomach, and at the same time much less nutritious. But as boiling extracts, in the first place, the more soluble, and therefore the saline parts; so, what remains is, in proportion, less alkalescent, and less heating to the system.

Boiling in digesters, or vessels accurately closed, produces effects very different from boiling in open vessels. From meat cooked in the latter, there is no exhalation of volatile parts; the solution is made with great success, and if not carried very far, the meat may be rendered very tender, while it still retains its most sapid parts; and this is esteemed always the most desirable state of boiled meat. If a small quantity of water only is applied, and the heat continued long in a moderate degree, the process is called stewing, which has the effect of rendering the texture of meat more tender, without extracting much of the soluble parts. This, therefore, leaves the meat more sapid, and in a state perhaps the most nourishing of any form of cookery, as we learn from the admirable essays and experiments of Count Rumford, who found very unusual effects produced on meat, by a low degree and long continued action of heat, both in the dry and humid way.

The application of a dry heat in the cookery of meat is of two kinds, as it is carried on in close vessels, or as it exposed to the air. The first of these which we shall consider, is baking. In this practice, meat has generally a covering of paste, by which any considerable exhalation is prevented, and the retention of the juices renders the meat more tender. In all cases, when the heat applied loosens, and in some measure extricates, the air without exhaling it, the substance submitted to this process is rendered more tender than when an exhalation is allowed. In broiling, an exhalation takes place, but as the heat of a naked fire is more nearly applied, the outer surface is in some measure hardened before the heat penetrates the whole, and thereby a great exhalation is prevented, while the whole is rendered sufficiently tender; but this kind of cookery is suited to meats that are chosen to be eaten a little raw. Nearly akin to this is the practice of frying, in which the meat being cut into thin slices, and laid in a pan over the naked fire, the heat is applied more equally to the whole substance. But as the part of the meat lying next to the bottom of the vessel would be suddenly hardened by the heat, it is always necessary to interpose some fluid matter, usually of an oily quality, as butter. A strong heat applied to the latter renders it empyreumatic, or at least less miscible with the fluids of the stomach; so that all fried meats are less easily digested than those of any other preparation. Sometimes, indeed, the same thing happens to baked meats, to which an oily matter, and that only, is added to avoid the too drying heat of the oven. It is obvious, that the preparations of stewing and frying may be frequently joined together; and according to there being more or less of the one or other, the effects may be imagined.—WATKINS' CYCLOPŒDIA.

COOLER, among brewers, distillers, &c. a large vessel wherein certain liquors are cooled after having been boiled.

COOPER, in the Trades, an artificer who makes casks, tubs, barrels, and all kinds of wooden vessels, which are bound together with hoops. This is unquestionably a very ancient trade, and is referred to 2000 years ago by the writers on rural economy in Rome. Their descriptions correspond in a good measure with the construction of casks in our day. It is not known when the business of a cooper was first introduced into this country, but it has been supposed it was derived from the French. Wood used for the purpose of cask-making, should be old and thick; straight trees are the best; from these are hewn thin planks, which are formed into staves. In France, we are told, the wood is prepared in winter; the staves and bottoms are then formed, and they are put together in summer.

CO-ORDINATES, in the theory of *Curves*, signifying any absciss, and its corresponding ordinate.

COPAIBA, or BALSAM OF COPAIBA, a liquid resinous juice, which comes from the trunk of the copaifera balsamum. Distilled in water, it yields a quantity of limpid essential oil.

COPAIFERA, a genus of the monogynia order in the decandria class of plants, ranking in the natural method under the doubtful order. There is only one species, the officinalis, which grows in Spanish America. Some trees do not yield any balsam, and those which do are distinguished by a ridge running along their trunks. These trees are wounded in the centre, and one of them will yield five or six gallons of balsam, but though they thrive after being tapped, they never give any more juice.

COPAL, is a beautiful white resinous substance, with a slight tint of brown. It is sometimes opaque, and sometimes almost perfectly transparent. When heated, it melts like other resins; but it differs from them in not being soluble in alcohol, nor in oil of turpentine without peculiar management. Neither does it dissolve in the fixed oils with the same ease as the other resins. When copal is dissolved in any volatile liquid, and spread thin upon wood, metal, paper, &c. so that the volatile menstruum may evaporate, the copal remains perfectly transparent, and forms one of the most beautiful and perfect varnishes that can well be conceived. The varnish thus formed is called copal varnish, from the chief ingredient in it.

COPARCENARY, in Law, an estate is said to be so held when lands of inheritance descend from the ancestor to two or more persons.

COPERNICAN *System*, is that system of the world in which the sun is supposed at rest; and the earth and the several plannets to revolve about him as a centre, while the moon and the other satellites revolve about their respective primaries in the same manner. The heavens and stars are here supposed at rest, and that diurnal motion which they appear to have from east to west is imputed to the earth's motion from west to east. This system was asserted and taught by many of the ancients, particularly by Ecphantus, Seleucus, Aristarchus, Philolaus, Cleanthes, Samius, Nicetas, Heraclides, Ponticus, Plato, and Pythagoras; from the last of whom it was anciently denominated the *Pythagorean System*.

COPERNICUS, NICOLAS, an eminent astronomer, born at Thorn in Prussia, Jan. 10, 1472, very early discovered a great bias for mathematics, which he pursued through all its various branches; and soon acquired so great a reputation, that he was chosen professor of mathematics at Rome, where he taught for a long time with great applause. He also made some astronomical observations there about the year 1500. Returning to his own country, he began to apply his knowledge to correct the system of astronomy which then prevailed. Of all the hypotheses of the ancients, none pleased him so well as the Pythagorean, which made the sun the centre of the system, and supposed the earth to move not only round the sun, but round its own axis also. After much profound contemplation, and many careful calculations, he removed the obscurities of this old system, and, in fact, much improved it. His discoveries and improvements he comprised in a book, printed in 1543, under the title of "Revolutionibus Orbium Cœlestium;" and the author received a copy of it a few hours before his death, on the 24th of May 1543, he being then 70 years of age. Few works have destroyed more errors, or established more important truths, than this great work of Copernicus. His noble theory was at first coldly received, or utterly rejected: but the labours of future astronomers at length obtained it a complete triumph. Corpernicus was also the first who demonstrated the double orbit of the moon; her menstrual motion about the earth, and her annual about the sun. Nor did this great man stop here: for, after laying a solid foundation of the celestial physics, he began the superstructure, by surmising a principle of attraction to be inherent in all matter. Copernicus also wrote a tract on Trigonometry; and has exhibited tokens of the versatility of his talents, as it is acknowledged that he had considerable skill as a painter, and was extremely well acquainted with the Latin and Greek languages.

COPERNICUS, the name of an astronomical instrument, invented by Whiston, to shew the motion and phenomena of the planets, both primary and secondary.

COPPER, a well-known metal, orange-coloured, nine times heavier than water, and very elastic. This fine metal, of which Great Britain produces abundance, is manufactured into numerous kinds of utensils, machinery in powder mills, sash frames, and several preparations of medicine. The oxide or rust of copper gives a beautiful green to porcelain, or glass: hence it is employed in making artificial emeralds. Copper is very abundantly used in covering the bottoms of ships. It is nearly forty years since the more intelligent among our shipowners introduced the use of copper as sheathing for their vessels, and the advantages soon became so conspicuous, as to lead to its adoption in most cases where the circumstances of the owners were such as to admit of the expense. In the navy, the more general use of copper has formed one of the main features of the improvements of the age, but at a great expense, in consequence of the rapid decay of the article; for while in a few cases copper would be found to last ten or fifteen years, in the great majority of instances it was worn out in a third, or less than a third, of the time. The Commissioners of the Navy, anxious to lessen this source of expense, and still more the uncertainty which attaches to the duration of vessels, particularly on foreign stations, from the decay of the copper, determined that a course of experiments should be instituted, to ascertain, if possible, the cause of this remarkable difference in the quality. Application was, therefore, made to Sir H. Davy, and the council of the Royal Society, for their assistance, also to the officers of his Majesty's Mint. At the Mint the investigation was undertaken by Mr. Mushet, who, from his situation in the melting department, had great advantages, both in experience, and in the command of machinery for making experiments. He was also supplied with specimens of copper by the Navy Board, taken from the bottom of a Dutch ship, the Batavia, captured in the year 1798, the copper of which, after 25 years' wear, was very perfect, though considerably reduced in weight. Mr. Mushet, after engaging in this important investigation, at last brought his labours to a satisfactory close, having arrived at a knowledge of the chemical process by which durability is communicated to copper, and having taken out a patent for the newly discovered method.

COPPERAS, the green salt sulphate of iron is so named; and also the blue salt sulphate of copper is sometimes also called copperas.

COPPERED, or COPPER-BOTTOMED, sheathed with thin sheets of copper, which prevents the worm eating into the planks, or filth accumulating on the bottom, whereby a ship is made to sail heavily.

COPPER-FASTENED, the bolts and other metal work in the exterior of the bottom, made of copper instead of iron; the advantage of which is, that the vessel may afterwards be coppered without danger of the sheathing corroding the heads of the bolts, which it is found to do, if they are made of iron; and to prevent the rapid corrosion and decay of copper, on the bottoms of ships, Sir H. Davy recommends the fixing of small masses or wires of tin, or some other readily oxidable metal, in contact with the copper sheathing, by which it is expected that the copper will be rendered so negatively electrical, that the sea water will act but slightly upon it.

COPULA, in Logic, the verb which connects any terms in an affirmative or negative; as riches make a man happy, where the word *make* is the copula.

COPULATIVE PROPORTIONS, are those wherein the subject and predicate are so joined by copulative conjunctions, that they may be severally affirmed or denied of one another.

COPYHOLD, in Law, a tenure for which the tenant has nothing to shew but the copy of the rolls made by the steward in the lord's court.—The customs of manors differ as much as the humour and temper of the respective ancient lords; so a copyholder by custom may be tenant in fee-simple, in fee-tail, for life, by the courtesy, in dower, for years, at sufferance, or on condition; subject, however, to be deprived of these estates upon the concurrence of those circumstances which the will of the lords, promulged by immemorial custom, hath declared to be a forfeiture, or absolute determination, of those interests; as in some manors the want of issue, in others the want of issue male, in others the cutting down timber, in others the non-payment of rent or fine. Yet none of these interests amount to freehold; for the freehold of the whole manor abides always with the lord only, who hath granted out the use of occupation, but not the corporeal seizin, or true possession of certain parts or parcels thereof, to these his customary tenants at will. If a person would devise a copyhold estate, he cannot do it by his will, but he must surrender to the use of his last will and testament, and in his will declare his intent; and here the lands do not pass by the will, but by the surrender thus made. Copyhold inheritances have no collateral qualities, which do not concern the descent, as to make them assets to bind the heir, or whereof the wife may be endowed, &c. They are not extendible in execution, but are within the acts against bankrupts, and the statutes of limitation.

COPYRIGHT, the right which an author may be supposed to have in his own original literary compositions; so that no other person, without his leave, may publish or make profit of the said compositions.

CORACIAS, *the Roller*, a genus of birds of the order of picæ, of which there are sixteen species, though some are only supposed to be varieties.

CORALLINA, or CORAL, a genus belonging to the order of vermes zoophyta. The species are distinguished by the form of their branches, and are found in the ocean attached to stones, bones, shells, &c. The corals were formerly believed to be vegetable substances, but are now known to be only a congeries of animals. The islands in the South Seas are mostly coral rocks covered over with earth. The little creatures, which have hardly sensation enough to distinguish them from plants, build up a rocky structure from the bottom of the sea, till it reaches the surface. Some of the coralline islands are much older than others, and it is probable, that as these submarine works are continually going on, new islands may be occasionally produced.

CORALLINES, in Natural History, were formerly reckoned plants, but, in the Linnæan system, are placed in the class zoophytæ, and defined to be submarine plants, like bodies consisting of many slender finely divided and jointed branches, or animals growing in the form of plants, having their stems fixed to other bodies, which stems are composed of capillary tubes, whose extremities pass through a calcareous crust, and open into pores on the surface. The branches are often jointed, and always subdivided into smaller branches, which are either loose and unconnected, or jointed as if glued together. They are distinguished from plants by their texture and hardness; they also yield in distillation volatile salt, and their smell when turbid resembles that of horns, and other animal substances. The corallines are distributed into the vesiculated, tubular, celliferous, and articulated winds.

CORALS, consist of nearly equal portions of carbonate of lime and animal matter.

CORBEILS, in Fortification, are baskets filled with earth, and so placed on the parapet, or elsewhere, as to leave openings through which to fire upon the enemy without being discovered.

CORD, MAGICAL, an instrument in great use among the Laplanders, and supposed to possess considerable virtues in certain magical rites and ceremonies. When properly prepared with knots, it is supposed to have power over the winds, and by means of it they will sell a favourable wind to any one that has faith enough to become a purchaser. If they untie only one of these knots, a moderate gale is to succeed; if two, it is much stronger, and if three, there is to be a storm.

CORDAGE, a general term for the running-rigging of a ship, as also for the rope which is kept in reserve to supply the place of such as may be rendered unserviceable.

CORDON, in Fortification, a row of stones made round on the outside, and set between the wall of the fortress which lies aslope, and the parapet which stands perpendicular.

CORDWAINERS, a term applied to the profession of shoemakers, and by which they are incorporated. The word is formed from the French *cordonnier*, and that from cordovan, a kind of leather brought from Cordova in Spain.

CORIANDRUM, CORIANDER, a genus of the digynia order in the pentandria class of plants, and in the natural method ranking under the 45th order umbellatæ. There are only two species, both herbaceous annuals, the leaves of which are useful for culinary and the seeds for medicinal purposes. The leaves of both species resemble those of parsley; but only one is cultivated, namely, the sativum, which has a small white fibrous root crowned by many parted leaves with broadish segments; in the centre is an upright branchy stalk, two feet high, having all the branches terminated by umbels of flowers, which are succeeded by globular fruit. It is propagated by seed sown in March. The seeds are carminative and stomachic.

CORONA AUSTRALIS, *the Southern Crown*, is an asterism interwoven with Sagittarius, and appearing like a wreath of foliage round one of the fore legs of the fabulous Centaur. There are twelve small stars in this constellation.

CORONA BOREALIS, *the Northern Crown*. This constellation represents a beautiful crown given by Bacchus, it is said, to Ariadne, the daughter of Minos, second king of Crete. Bacchus, continues the fable, married Ariadne, after she was basely deserted by Theseus, king of Athens; and after her death, the crown that Bacchus had given her, was made a constellation. This asterism was known to the Hebrews by the name of *Ataroth*, and by this name the stars in Corona Borealis are so called to this day in the East.

Boundaries and Contents.—This constellation lies between Boötes and Hercules, and is easily known by four stars, α, γ, δ, ϵ, forming a crescent. It contains 21 stars, of which α, called also *Gemma*, is of the 2d magnitude. Gemma rises N. E. by N. $\frac{3}{4}$ E. and has 27° 19′ 39″ of north declination, and 231° 46′ 21″ of right ascension. There are likewise six stars of the 4th magnitude, and the others are less in size. Meridian altitude of α, 65° 48′ 39″.

CORK. is a substance analogous to wood; it is the exterior bark of a tree belonging to the genus oak, which grows wild in the southern parts of Europe. When the tree is fourteen or fifteen years old it is fit to be barked, and may be done successively for several years. The bark always grows up again, and its quality improves as the age of the tree increases. If the bark is not taken off in due time, it splits and peels off of itself, being pushed away by the second growth. The best bark comes from Spain and Portugal; it is taken off in sheets, care being used in keeping them as large as possible. After it is detached from the tree the Portuguese burn or char it, laying the convex side of the bark to the fire, in order to straighten and swell it. It is then piled in stacks ready for sale.

Cork is formed into soles for shoes, into corks and bungs for stopping bottles, &c. into a floatage for the nets of fishermen; it is employed generally, though perhaps with a considerable degree of error, in teaching the art of swimming; it is also ingeniously used on account of its lightness, when an amputation of the human leg has been necessary, to supply the deficiency. The Spaniards line stone walls with it, which not only renders their houses very warm, but corrects the moisture of the air; the Egyptians made coffins of it, which being covered in the inside with a resinous composition, preserved their dead bodies. It is burnt, to make that light black substance called Spanish black, from its having been first made in Spain. Cork bark has not only been applied as above, but also in the preservation of life when in danger of shipwreck.

CORK *Fossil*, a kind of stone which is a species of amianthus, consisting of flexible fibres loosely interwoven, and resembling cork. It is fusible by fire, and forms a black glass.

CORK *Jacket*, a sort of waistcoat composed of four pieces of cork, two for the breasts and two for the back, the whole covered with canvass, with two holes to put the arms through. It was invented by Mr. Dubourg, but has been improved by Dr. Wilkinson by cutting the cork into small pieces, and quilting them between two canvass waistcoats. The most timorous may venture, with one of these on, into a rough sea.

CORN, the grain or seeds of plants separated from the spica or ear, and used in making bread. It is contrary to the statute to buy or sell corn in the sheaf, or otherwise than by Winchester measure.

CORN, in Medicine or Surgery, a hard tubercle like a flat wart, growing in several parts of the feet, especially upon the joints of the toes. This disorder is attributed to the wearing of too straight or narrow-toed shoes, which never fail to produce these tubercles, especially if the person is obliged to stand or walk much, and in the summer time. Various are the methods used for removing these callosities of the skin and cuticle; some by the knife, and others by the application of emollient and caustic, or eroding medicine.—As few things are more troublesome than corns in the feet to those who have much walking, we may observe, that the pressure may be prevented in the following manner: Take a piece of linen, spread with any emollient plaster; lay one piece over another, eight, or ten, or more times, and cut a hole in the middle of them, exactly the same size and circumference as the corn, then apply it in such a way that the corn enters the hole in the plaster, and it is thus defended against the contact of shoes and stockings.

CORNER STONES, in Architecture, the two stones which stand one in each joint of the chimney, commonly made of Reigate or free-stone.

CORNET, in the Military art, the third commissioned officer in a troop of horse or dragoons. He commands in the lieutenant's absence, his principal duty being to carry the standard near the middle of the first rank of the squadron.

CORNET, among the Ancients, a musical instrument resembling a trumpet used in war.

CORNUCOPIÆ, or HORN OF PLENTY, among Painters, &c. is a large horn, out of which issue fruits, flowers, &c. Upon models, the cornucopiæ is given to all deities, genii, and heroes, to mark the felicity and abundance of all the wealth procured by the goodness of the former, or the care and valour of the latter.

COROLLARY, a consequence drawn from something advanced or demonstrated.

CORONATION, the public and solemn confirming the title, and acknowledging the right of sovereignty belonging to a king or queen; at which time the prince swears reciprocally to the people, to observe the laws, customs, and privileges of the kingdom, and to act and do all things conformable thereto.

CORONER, an ancient officer at the common law, and so called because he acts chiefly in pleas of the crown. By statute no person can be chosen coroner unless he have land in fee in the county. The electors also must be freeholders. The coroner's duty is to inquire how any person came by an untimely death, for which purpose he issues a precept to the constables to return a competent number of persons to serve as a jury, which must consist of twelve at the least. He may commit, after inquisition, any person found guilty by the jury of murder or manslaughter, and may bind over the witnesses to give evidence. It is also the duty of the coroner to inquire of treasure that is found, who were the finders, and also who is suspected thereof. By 25 George II. the coroner shall have 20*s*. and 9*d*. a mile for the distance he shall travel to take an inquisition, paid him out of the county rates.

CORPORAL, an inferior officer in a company of foot, who has charge over one of the divisions, places and relieves sentinels, and keeps order in the squad to which he belongs; he also receives the word from the inferior rounds, which pass by his corps-de-garde. This officer carries a fusee, and is commonly an old soldier: there are generally three corporals in each company.

CORPORATION, a body politic or incorporate, so called because the persons or members are joined into one body, and are qualified to take and grant, &c. Corporations are either spiritual or temporal: spiritual, as bishops, deans, archdeacons, parsons, vicars, &c.; temporal, as mayor, community, bailiffs, burgesses, &c. And some corporations are of a mixed nature, composed of spiritual and temporal persons, such as heads of colleges and hospitals, &c. All corporations are said to be ecclesiastical or lay: the former are either regular, as abbeys, priories, chapters, &c. or secular, as bishoprics, deaneries, archdeaconries, &c.; lay, as those of cities, towns, companies, or communities of commerce, &c.

Corporations may be established in three different ways, *viz*. by prescription, letters patent, or act of parliament; but they are most commonly established by patent or charter. The corporation of London is by prescription; but though corporations may be by prescription, yet that prescription did originally derive its authority by a grant from the king. A corporation may be dissolved; for it is created upon a trust, and if it be broken it is forfeited. No person shall bear office in any corporation but such as have received the sacrament, taken oaths, &c. and none are to execute in a corporation for more than a year. A corporation cannot sue or appear in person, but by an attorney. Ordinances made by corporations, to be observed on pain of imprisonment, forfeiture of goods, &c. are contrary to Magna Charta. Actions arising in any corporation may be tried in the corporation courts; but if they try actions not within their jurisdictions, and encroach upon the common law, they are liable to be punished for it. The corporation of the city of London is to answer for all particular misdemeanors committed in any of the courts of justice within the city, and for all other general misdemeanors committed in the city.

CORPS, in Military affairs, means a body of soldiers. *Corps de garde*, is a post in an army sometimes under cover, or in the open air, to receive a number of men who are relieved from time to time. The term is also applied to the men who watch at the post.

CORPUS CUM CAUSA, in Law, a writ issuing out of the Chancery to remove the body and record into the King's Bench, there to lie till judgment shall be satisfied.

CORPUSCLE, in Physics, a minute particle or atom, of which natural bodies are formed.

CORRELATIVE, something opposed to another in a certain relation, as father and son, light and darkness, motion and rest.

CORROSION, the action of gnawing away by degrees the continuity of the parts of bodies.

CORROSIVE SUBLIMATE, the old name for the chloride of mercury, called also oxymuriate of mercury, and muriated mercury.

CORROSIVES, in Surgery, medicines that corrode whatever part of the body they are applied to, as burnt alum, white precipitate of mercury, white vitriol, red precipitate of mercury, and lapis infernalis.

CORRUPTION, the destruction of the proper mode of existence of any natural body.

CORRUPTION *of Blood*, in Law, an infection accruing to a man's state, attainted of felony and treason, and to his issue; for as he loses all to the prince, &c. his issue cannot be heirs to him, or to any other ancestor by him; and if he were noble, his heirs are rendered ignoble.

CORSELET, a little cuirass, or, according to others, an armour or coat made to cover the whole body, anciently worn by the pikemen usually placed in the front and flanks of the battle, for the better resisting the enemy's assaults, and guarding the soldiers placed behind them.

CORTEX, in Botany, the outer rind or bark of trees.

CORUNDUM, a mineral, of which there are two species, the perfect and the imperfect. Perfect corundum, or sapphire, is found in the East Indies, particularly in Peru and Ceylon; and it is most commonly crystallized. The general colour is blue, sometimes without colour, others red, purple, yellow, and green.

CORUS, a measure in Jewish antiquities, answering to the omer, containing 75 gallons 5 pints for liquids, and 32 pecks 1 pint dry measure.

CORUSCATION, a gleam of light issuing from any thing. It is chiefly used for the electrical fluid, when it becomes visible, as the flash of lightning, &c.

CORVUS, *the Crow*, one of the old constellations, lies south of Virgo, north of Hydra, east of Crater, and west of Hydra Continua. This constellation is said to have its name from the crow into which Apollo metamorphosed himself when he escaped from the giant Typhæus. Castor and Apollo were the same. Typhæus and Typhon are the same. The Crow rises in the east, when the Twins come to the meridian. Typhon was a type of the lower hemisphere; the Crow then was the symbol of the Twins, having possession of the meridian.

Corvus, the raven or crow kind, a genus of birds of the order of picæ. There are 19 species, the principal of which are, 1. The corax or raven. 2. The corone or carrion crow, very much resembles the raven in form and habits. 3. The frugilegus or rook, is the corvus of Virgil; no other species of this kind being gregarious. 4. The cornix or Royston crow in its habits resembles the rook, feeding on insects, and flying in great flocks. 5. The dauricus, or white-breasted crow. 6. The monedula, or jackdaw, weighs about nine ounces. 7. The glandarius, or jay, is one of the most beautiful of British birds. 8. The caryocatactes, or nut-cracker, is less than the jackdaw, the general colour of the body is of a rusty brown, and the wings are black, with white spots. These birds seldom visit England, but abound in Germany. 9. The pica, or magpie, in its manners approaches near to the crow, feeding both on animal and vegetable food. 10. The graculus, or red-legged crow, is of a slender make, active and thriving, much taken with glitter, and apt to catch up lighted sticks, whereby it has been even known to set houses on fire. It is found in Cornwall, North Wales, and Scotland. 11. The cristatus, or blue jay, is smaller than the common jay. This species is peculiar to North America. 12. The Canadensis is a small bird, the general colours of which are yellow-white, blackish-brown, and a pale ash. These birds inhabit Canada and Hudson's Bay, where they are called whiskijohn and whiskijack.

CORYLUS, *the Hazel*, a genus of the polyandria order, in the monœcia class of plants; which in the natural method ranks under the 60th order, amentaceæ. There are three species, all of the shrub kind, having several varieties, valuable for their nuts, and their usefulness in copses and hedges. The wood is useful for poles, hoops, spars, handles, fishing rods, &c. A kind of chocolate has been prepared of the kernels of the nuts; and the oil expressed from them is used by painters and chemists.

COS, *the Whetstone*, a genus of vitrescent stones, of which there are several kinds, some consisting of rougher, and others of smoother particles; and used not only for whetstones, but also for mill-stones and other purposes.

COS-TURCIA, Turkey Stone, a species of stones of the garnet kind, and of the siliceous class. It is of a dull white, and often of an unequal colour. It strikes fire with steel, and effervesces with acids. It is used as a whetstone, and those of the finest grain are the best hones for cutting tools, razors, lancets, &c.

COSMETIC, in Physic, any medicine or preparation which renders the skin soft and white, or helps to beautify and improve the complexion, as lip-salves, cold creams, ceruss, &c.

COSMICAL, an astronomical term for one of the poetical risings of a star; thus a star is said to rise cosmically when it rises with the sun.

COSMOGONY, the science of the formation of the universe; or that which discusses the particulars of the creation of the world.

COSMOGRAPHY, a description of the several parts of the visible world; or the art of delineating the several bodies, according to their magnitudes, motions, &c. It consists of two parts—geography and astronomy.

COT, in Naval affairs, a particular sort of bed-frame, suspended from the beams of a ship, for the officers to sleep in. It is made of canvass, sewed in the form of a chest, about six feet long, one foot deep, and two or three wide, and is extended by a square wooden frame, with a canvass bottom, on which the bed or mattress is laid. It is reckoned much more convenient at sea than either the hammocks or fixed cabins.

COTTON is the produce of the gossypium, a plant about the size of a currant bush, a native of the torrid zone, though it is produced in parts of Turkey, so far as 44 or 45 degrees from the equator. The finest cotton is known by the name of cat's-claw, from its singular appearance when it breaks the pod. This kind was accidentally discovered at the island of Bourbon, and was supposed to have been introduced among some seed sent from South America to the Mauritius. The soil should be extremely well prepared, and of the best quality, for the reception of cotton seed, which is usually sown in November or December, after the periodical rains in tropical climates, and ripens in May or June; when the numerous pods, which are about the size of large gooseberries, break, and display their downy contents. These are picked, and after the husks have been disengaged, the cotton is put into a small mill, consisting of two bright steel rollers, each about an inch in diameter, set parallel within the distance of about the 20th part of an inch. These rollers move different ways, and draw the cotton through between them, while the seeds are forced out of the respective little balls of down in which they are enclosed, and drop into a bag. The generality of cotton is white; but some is of a nankeen colour, and is invaluable in the manufacture of that article, as it fades very little, even with long use and frequent washing. The elasticity of cotton is inconceivable! It may be pressed into a 50th part of the space into which the strongest packers can reduce it by personal exertion: large screws are erected at many sea-ports where cotton is shipped, for the purpose of bringing the bales into the smallest compass, so as to save freight. Cotton can only be imported as a raw material, in which form it comes to us from the Levant, the West Indies, America, and the East Indies. In the last quarter, there are some kinds indigenous, but some are exotics. It is a highly dangerous cargo, being very subject to take fire if at all damp when packed, or if the smallest spark should reach it; in either case, it will burn very slowly for weeks; but when the hold is opened, and air supplied, bursts forth with inconceivable fury. There is a species of silky down produced in pods, (similar to those of the cotton plant,) on a very large tree, called the seemul. It is only fit to fill beds. Specimens of it have passed through various hands; but this kind of cotton is so peculiarly glossy, and the fibre so short, that it could neither be carded nor spun. When mixed with rabbit's fur, &c. to make hats, it is always separated. It also failed in paper-making; otherwise its abundance and cheapness would have rendered it highly important.

Cotton *Manufacture*, in Commerce, is now one of the most important branches of British industry. *Cotton Spinning*, the process of reducing cotton wool into yarn or thread. The method formerly used for this purpose was by the hand, upon a machine called a one-thread wheel. But about 1767, Mr. Hargrave, an operative weaver of Lancashire, made a machine, by which a great number of threads might be spun at once, and for which he obtained a patent. This is called a jenny, and with it, one person can spin 100 hanks in a day; each hank containing 840 yards.

Carding of Cotton, as a preparation for spinning, used formerly to be performed by the hand, with a single pair of cards on the knee, but this being a tedious method, and ill adapted to the rapid operations of the spinning machines, new ways were contrived. The first improvement was by Mr. Hargrave, and consisted in applying two or three cards to the same board, and fixing them to a stool or stock; with these, one woman could perform three times as much as by the common way. But a more expeditious method is by the cylinder cards, to the invention of which several persons lay claim. The next great improvements in the cotton manufacture were from Mr. (afterward Sir Richard) Arkwright, of Cromford, in Derbyshire. He obtained a patent for his new system of spinning cotton in 1769, and in 1775 another, for engines to prepare the materials for spinning. The validity of this second patent was set aside in 1781, but in 1785 he obtained a verdict that established the sufficiency of his patent. In the same year, however, he was cast in another trial, on the ground of his not being the original inventor of that simple and beautiful contrivance the *Twist* or *Water Frame*. Arkwright still persevered in declaring himself the inventor, and on the 10th of November, 1785, he moved, in the court of King's Bench, for a new trial; but his rule was refused; and on the 14th of November, 1785, the court of King's Bench gave judgment to cancel the letters patent. It may be proper to observe, that Sir R. Arkwright's contests with the rival manufacturers of Lancashire, related chiefly to the operation of carding. The Annual Register for the years 1781 and 1785, or the Gentleman's Magazine, probably contains faithful records of all these trials, rules, and issues.

The result of Arkwright's inventions is a combination of machinery, by which cotton is carded, wove, and spun with the utmost exactness. To these improvements, the country is indebted for the great extent of its cotton manufactures; large works having been erected in England and Scotland, many containing several thousand spindles, driven by large water-wheels, some of such extent as to spin at the rate of 1000 yards of twist in a minute. Another machine has been invented, called a mule, because it is a kind between Mr. Hargrave's and Mr. Arkwright's. This also promises to be of great use in spinning cotton yarn for muslins to a degree of fineness equal to those of India. *See* Mill.

The operations which cotton undergoes in its passage from the raw material to the state of thread, are various and multiplied in proportion to the fineness required, and the different uses to which it is destined. If we analyze these operations, they resolve themselves into the following: Batting, carding, doubling, drawing, and twisting. The three latter are never performed singly, but are variously joined in the same machine; and the same elementary processes are oftentimes repeated in different machines, with various and different effects. With reference to these effects, the operations which cotton undergoes, may be denominated batting, carding, drawing, and doubling, roving, and spinning.

Batting, is that operation which prepares the cotton for carding, by opening and disengaging the hard compressed masses in which it comes from the bales. It is performed by beating the cotton with sticks on a square frame, across which are stretched small cords, about the thickness of a goose quill, with intervals sufficient to suffer the seed, leaves, and other adventitious matter, to fall through. When a hard matted or compressed mass of cotton is smartly struck with a stick, the natural elasticity and resiliency of its fibres, gradually loosen and disengage them, and the cotton recovers by repeated strokes all its original volume. During this operation the seeds, &c. which adhere, are carefully picked out by the hand, and the cotton rendered as clean as possible. Batting is generally and best performed by hand, though the scarcity of hands and cost of labour have rendered other contrivances necessary.

Carding, is that operation in which the first rudiments of the thread are formed. It is performed, as we have before stated, by cylinders covered with wire cards, revolving with considerable swiftness in opposite directions, nearly in contact with each other, or under a kind of dome or covering, the under surface of which is covered with similar cards, whose teeth are inclined in a direction opposite to those of the cylinder. By this means the separation of almost every individual fibre is effected, every little knotty or entangled part disengaged, and the cotton spread lightly and evenly over the whole surface of the last or finishing cylinder, from which it is stripped by the contrivance we have already described.

For jenney spinning, which is still in use for the coarser kinds of thread, the cardings are stripped off in separate lengths. The finishing cylinder is covered with the ordinary cards nailed on in stripes across, and the cotton contained between the margins or intervals of each stripe, forms one carding, whose length of course depends on the width of the engine, or cylinder. When stripped off by the crank and comb, it forms a loose and shapeless film, which falling on the surface of a plain wooden cylinder, the lower half of which revolves within a hollow shell or casing, the cotton in its passage is rolled up and delivered at the other side in perfect and cylindrical cardings.

For mule or water spinning, the finishing cylinder is covered with spiral or fillet cards, and the cotton being taken off in one continued fleece, and contracted by passing through the funnel and rollers, forms one endless and perpetual carding, which is interrupted only, or broken, when the tin can that receives it is completely filled.

In the jenney carding, the fibres of the cotton are disposed across or at right angles to the axis of the carding; in the perpetual carding they are disposed longitudinally, or in the direction of its length, and it is this circumstance which renders the carding destined for mule or water spinning, inapplicable to the jenney, and *vice versâ*.

Drawing, and *Doubling*, is one of the preparatory processes for which we are indebted wholly to Sir Richard Arkwright, and belongs exclusively to the mule, or water spinning. The doubling, or passing three or four cardings at once through a system of rollers, by which they are made to coalesce, is intended to correct any inequalities in the thickness of the cardings, and also to admit of their being frequently drawn out or extended by passing through the rollers. The effect of this frequent drawing is to dispose the fibres of the cotton longitudinally, and in the most perfect state of parallelism. The operation of carding effects this in a certain degree; yet the fibres, though parallel, are not straight but doubled, as may easily be supposed from the teeth of the cards catching the fibres sometimes in the middle, which become hooked or fastened upon them. Their disposition is also farther disturbed by the taker-off or comb, which strips them from the finishing cylinder; and though the general arrangement of the fibres of a carding is longitudinal, yet they are doubled, bent, and interlaced in such a way, as to render the operation we are now speaking of absolutely necessary. When the cardings have been passed four or five times through the drawing frame, every fibre is stretched out at full length, and disposed in the most even and regular direction; and though the average length of a fibre of cotton is not two inches, yet the finished drawing, as these prepared cardings are now termed, has all the appearance of a lock of Jersey wool, whose fibres, six or eight times as long as those of cotton, have been carefully and smoothly combed.

Roving, is that operation by which the prepared cotton, as it comes from the carding engine, or drawing frame, is *twisted* into a loose and thick thread, and wound upon a spindle or bobbin.

In jenney spinning, the cardings are roved without any other preparation, by a machine called a roving billy; for a description of which, with other particulars relative to jenney spinning, *see* Jenney.

In mule or twist spinning, the prepared carding or drawing, as it is termed, is again passed through a system of rollers, and is twisted, either by a rapidly revolving can, into which it is delivered from the rollers, or by a fly and spindle similar to those of the flax wheel; in the latter case it is wound on the bobbin by the machine; in the former, it is received in the conical can in which it acquires the twist, and is afterwards wound upon bobbins by the smaller children of the mill.

Sir Richard Arkwright always employed the revolving can, and it is still employed in many of the first mills in the country. The roving frame with fly and spindle, which is in fact nothing more than the twist frame of Sir Richard, is now however very generally in use, especially since later improvements have removed objections to the machine, which rendered its use heretofore inconvenient. *See* Frame.

The operations through which the thread passes after it has received the first twist are various, and depend greatly on the use it is intended for. The finer it is required, the oftener it is drawn out and twisted, till by degrees, as in the process of wire-drawing, it is brought down to the fineness required. The rovings are therefore distinguished into first, second, and third, according to the number of operations they have gone through.

Spinning, is the last operation which the thread undergoes in the series of processes employed in converting it into thread, and is that in which it receives the final extension and twisting. It is performed either on the jenney, twist frame, or mule.

The thread is of two kinds, *viz. twist*, so called from its being harder twisted than the other, forming a stouter thread, and used for the web or warp of piece goods; and *weft*, which is a looser, softer thread, and used for the woof. The weft is delivered to the weaver in small oblong rolls called *cops*, in the state they are stripped off the spindles of the mule or jenney. When these are used, a small pointed piece of wood or skewer is carefully passed through the axis of the cop into the place formerly occupied by the spindle, and one end of it being held between the teeth, the thread is wound off the cop upon the weaver's bobbin by a wheel somewhat smaller in size, but the same in principle as the common one-thread wheel, on which all the spinning was formerly performed. This is generally done by children, and the bobbins are then ready for the shuttle. Twist undergoes several operations before it is ready for the loom. It is delivered by the spinner either in hank or cop.

Hank twist is that which is spun on the water frame, from the bobbins of which it is reeled into hanks of a determinate length, each measuring 840 yards. The value and fineness of the thread are proportionate to the number of hanks in a pound, and they are denominated by numbers, as Nos. 20, 50, 100, &c. which express the hanks which a pound of twist contains. In this state it is generally *sized*, an operation which is intended to give additional strength and tenacity to the thread, and enable it to support the different operations in its passage to the loom. It consists in impregnating the thread fully with thin size, chiefly formed of wheat flour boiled in water, with the addition of a little glue. The twist is carefully worked in this, and afterwards wrung and dried. The thread acquires considerable strength by this operation, and the loose fibres are all firmly attached or glued to its surface. It is then delivered to the winder.

Winding, is that operation by which the thread is transferred to the warping bobbin, either from the cop, hank, or twist frame bobbin.

Formerly this was chiefly done by females, and the work was carried home and performed by any of the family not engaged in domestic concerns, on a small wheel that turned two bobbins at a time. This mode is still in use, but the work has been greatly abridged and facilitated by the use of machines of various constructions.

Cop twist is that which is spun on the mule or jenney. It is reeled only occasionally, to ascertain its value and fineness, and is delivered in cops to the winder.

The next operation is that of *warping*, or the formation of the web. The machine on which this is performed is an octagonal prism five or six feet high, and somewhat less in diameter, revolving vertically, and put in motion by a band and pulley placed under the seat of the warper. The bobbins which furnish the thread are suspended horizontally in a frame on one side. Twenty-eight or thirty threads, forming together a system called a *half beer*, are wound round the prism in a spiral form from top to bottom. The machine is then turned the contrary way, and the thread wound round the prism upwards from bottom to top, and this is repeated backwards and forwards till a sufficient number of *half beers* have been wound to form a web of the breadth required. When finished, and the ends properly secured, the whole is wound off and coiled upon the hand into a round ball called the *warp*. If the thread has been previously sized in the hank, it is now ready for the loom, but if the warp is made of cop twist, that operation is next performed.

The warps are boiled several hours in water till they are thoroughly penetrated and softened; after draining some time they are then uncoiled and worked in the size till fully impregnated, after which the superfluous size is squeezed out, and they are suspended on poles to dry: the warp is then ready for the loom.

Without this operation of sizing, which, as we have before observed, gives strength and tenacity to the thread, it would not support the friction of the loom. Two threads are passed between each dent of the reed, and at each stroke of the treadle one ascends whilst the other descends. There is therefore a constant friction of the threads upon each other, as well as against the teeth of the reed. The motion of the reed itself also backwards and forwards, and of the healds up and down, is very severe upon the warp, and unless it has been well penetrated by the size, and its fibres well cemented or glued together, this continual rubbing is sufficient to destroy its texture.

Good sizing prevents this, but it is still further aided by another operation called *dressing*, which is performed by the weaver himself, after the warp is got into the loom. This consists first, in applying with a brush a kind of paste made of wheat flour well boiled, to which is often added a small portion of common salt; sometimes of potash, and sometimes even a little tallow. It is in fact a repetition of the operation of sizing, with this difference, that the dressing is applied chiefly to the surface of the thread, which is slightly smeared with the paste, and brushed uniformly in one direction from the healds to the beam, by which means the loose fibres are all disposed evenly one way, and firmly glued fast to the thread.

In summer the warp is dried simply by fanning it, but in winter, and in damp cold weather, a hot iron is lightly passed over it. It is then dressed again with a brush dipped in tallow or butter, with which it is slightly greased. This gives suppleness and smoothness to the thread, and greatly diminishes the friction of the healds and reed. As such a portion of the warp as is extended between the healds and beam can alone be dressed at one time, this is woven, and the dressing repeated again upon another portion, and so on, alternately dressing and weaving till the whole of the web is finished.

Various improvements on these different processes have taken place of late years, which have made greater or less progress in proportion to their utility and importance. We shall enumerate, therefore, not only those of recent date, but such as, though known some time, have not been generally adopted.

The weaver's bobbin is still wound by hand in the manner already described, though the use of a small machine, by which twenty bobbins or upwards are wound at once, is daily gaining ground. They are to be seen now in almost every weaver's cottage where several looms are employed. This labour is further abridged by a very ingenious contrivance, for which a patent has been obtained. The cops, instead of being wound, are compressed or squeezed till they are small enough to enter the shuttle. The winding here is done away, and the cops thus compressed are preferred by the weavers to the common bobbin. In those large establishments where the different processes, such as spinning and weaving, are carried on together, the cops are spun small enough to enter the shuttle without compression. The weft is transferred at once from the spindle of the mule to the weaver's shuttle, and the time and waste of winding, and even of compressing, saved entirely.

On the same principle also, a considerable reduction has been made in the labour of reeling and winding twist. Till within a late period, the practice has uniformly been to reel it into hanks from the bobbin it was spun on, to size it in the hank, and then wind it for warping. An obvious reduction of this labour is to warp it directly from the bobbin it is spun on, and size it in the warp like cop twist. For reasons, however, which it will not be necessary here to enter into, this has been found impracticable. It is, however, transferred to the warping bobbin, without the intermediate labour and waste of reeling, and the sizing is done in the warp. Considerable improvements in the mode of sizing have been made within these few years, especially in the sizing of warps.

Formerly, the practice was to work the warp in the warm size by the hand, the heat of which was of course limited to that degree which could be readily borne by the workman. Experience having proved, that the hotter the size, the more evenly and perfectly was the warp penetrated, various contrivances were adopted for applying it at a high temperature. Amongst others, are oblong troughs furnished with several pairs of rollers, through which the warp passes, and is strongly compressed whilst immersed in the hot size. Mr. Marsland's idea of placing the twist in an exhausted receiver, and admitting the hot size, promises considerable advantages in some cases, and when the plan has been matured, will no doubt be susceptible of many applications.

But the greatest improvement that has been made in these different processes, and one that must eventually effect a complete revolution in the whole system, is Messrs. Ratcliffe and Ross's mode of dressing. Hitherto this operation has been performed by the weaver in the manner we have already described, at the expense of one-third of his time and labour. As it is only possible for him to dress at once as much of the work as is contained between the healds and beam, he is scarcely got settled to his work, after each operation, before he is again called off to dress another portion. By this continual interruption of one species of labour by another totally different, it must be obvious to every one, that not only much time is lost, but that the labour itself cannot be equally well performed.

There is a delicacy and certainty of touch in weaving, dependent on long habit and experience, and on which the evenness and goodness of the cloth depends. If the force with which the woof or weft is driven up by the reed, be not always alike, if it is greater at one time and less at another, the cloth will be thicker and thinner at those places, and such is the nicety on which this depends, that the most experienced weaver, after an interruption of some hours, cannot at once regain it.

Messrs. Ratcliffe and Ross dress the whole of the warp before it is wound upon the beam, the labour of the weaver is therefore uninterrupted, and his attention directed solely to one object. This alone is a great point gained, but it is attended also by other, not less important, advantages. Great part of the intellectual skill required in weaving is in the dressing and beaming of the warp; the mere mechanical part of throwing the shuttle, &c. is soon acquired, even by a boy. A more accurate division of labour, by reducing the beaming and dressing to a system by which they are better, more economically, and more expeditiously performed than before, has removed the great difficulty in the art of weaving, and rendered it in a great measure the employment of children.

From what we have already said, it will appear that the object in dressing and sizing is nearly the same, and Messrs. Ratcliffe and Ross, by this improved mode of dressing, have succeeded in reducing these operations to one. They have gone still further; they have done away the necessity of warping, by forming the web at once from the bobbin, and thus reduced the warping, sizing, dressing, and beaming, to one operation. A thousand bobbins and upwards supply the materials for the warp, which in its progress is properly disposed and arranged, sized, dressed, and finally wound upon the beam. This improvement, which may justly be regarded as the most important that has taken place in weaving, since the invention of the fly shuttle fifty years ago, must in the end effect a complete change in the system of labour. Great however as its advantages are, some time must necessarily elapse before it can be accommodated to general use. In large establishments, where the different processes of the manufacture are carried on together, such as spinning, weaving, and the labour immediately connected with them, it has been adopted with the happiest success, but the weaving in this country is chiefly done in the cottages of the poor, and to their use the costly and bulky apparatus of Messrs. Ratcliffe and Ross is not adapted.

To derive all the advantages possible from this improvement, therefore, it will be necessary either that the weaving be done in large shops, to each of which a dressing machine may be attached, or that the warps be delivered to the country weavers ready dressed and wound upon the beam. The former plan is daily gaining ground, and perhaps it is not difficult to foresee, that at no very distant period all the weaving of the country will share the fate of the spinning, and quit the cottage for those larger establishments in which it will be susceptible of better management, and more accurate division of labour.

The last improvement, which we shall notice in the manufacture of cotton, and which, when once established, will complete what Arkwright has so happily begun, is that of weaving by machinery. Various attempts have been made of late years to apply the great moving powers, steam and water, to the common loom. *See* Loom.

COUCH, or Coat, in Painting, a term for each lay of colour, either in oil or water, with which the artist covers his canvass, wall, wainscot, or other matter, to be painted.

COUCHING, in Surgery, the operation of removing a cataract, which is done by a peculiar needle, called the couching needle.

COULTER, in Husbandry, an iron instrument fixed in the beam of a plough, and serving to cut the edge of each furrow.

COUNCIL. In this country, the law, in order to assist the king in the discharge of his duties, the maintenance of his dignity, and the exertion of his prerogative, hath assigned him a diversity of counsellors with whom he may advise.

1. The first of these is the high court of parliament.

2. The peers of the realm are, by their birth, hereditary counsellors of the crown.

3. A third council belonging to the king, are, according to Sir Edward Coke, his judges of the courts of law, for law matters. And this appears frequently in the English statutes, particularly 14 Edward III. c. 5, and in other books of law. So that when the king's council is mentioned generally, it must be defined, particularized, and understood, according to the subject matter; and if the subject be of a legal nature, then by the king's council is understood his council for matters of law; namely, his judges.

4. But the principal council belonging to the king is his privy council, which is generally, by way of eminence, called The Council, composed of eminent persons, the number of whom is at the sovereign's pleasure, who are bound, by oath, to advise the king, to the best of their judgment, with all the fidelity and secrecy that becomes their station. The king may declare to, or conceal from, his privy council whatever he thinks fit, and has a select council out of their number, commonly called the cabinet council, with whom his majesty determines such matters as are most important, and require the utmost secrecy. All proclamations from the king and the privy council ought to be grounded on law, otherwise they are not binding to the subject. Privy counsellors, though but gentlemen, have precedence of all the knights and younger sons of barons and viscounts, and are styled right honourable.

Council, *Common*, in the city of London, a court in which are made all by-laws which bind the citizens. It consists, like the parliament, of two houses, an upper, composed of the lord mayor and aldermen; and a lower, composed of a number of common councilmen chosen by the several wards, as representatives of the body of the citizens.

COUNSELLOR at Law, a person retained by a client to plead his cause in a court of judicature. There are two degrees of counsel, *viz.* barristers and serjeants. Barristers are called to the bar after a certain period of standing in the inns of court. After 16 years' standing, they may be called to the degree of serjeant. The judges of the courts of Westminster Hall are always admitted serjeants before they are advanced to the bench. From both serjeants and barristers the king's counsel are usually selected, the two principal of whom are the attorney and solicitor-general. Counsel are supposed to plead gratis, and can maintain no action for their fees; and to encourage in them a freedom of speech in the lawful defence of their clients, a counsellor is not answerable for any matter by him spoken, though it should prove groundless, and reflect on the reputation of another, provided it relates to the cause which he espouses, and is suggested in his client's instructions. And notwithstanding counsellors have a special privilege to practise the law, yet they are punishable for misbehaviour by attachment. No counsel is allowed to a prisoner upon a general issue of indictment of felony, unless some point of law arise; for the court is the prisoner's only counsel.

COUNT, originally, a nobleman who possessed a domain erected into a county. The dignity is a medium between that of a duke and a baron. It is now merely a title of honour.

Count, in Law, is the original declaration of complaint in a real action, as a declaration is in a personal one.

COUNTER APPROACHES, in Fortification, lines and trenches made by the besieged to attack the works of the besiegers, or to hinder their progress. The line of counter approach is a trench made by the besieged from their covered way to the right and left of the attacks, in order to scour the enemy's works.

COUNTER BATTERY, is one raised to play upon another to dismount its guns.

COUNTER-GUARD, in Fortification, a work raised before the point of a bastion.

COUNTERMARCH, a change of the face or wings of a battalion, whereby those that were in the front come in the rear. Also the returning or marching back again.

COUNTERMINE, in War, a well and gallery driven and sunk till it meets the enemy's mine, to prevent its effects.

COUNTERPART, in Music, denotes that one part is to be applied to another. Thus the bass is said to be the counterpart to the treble. In Law, it is the duplicate or copy of an indenture or deed.

COUNTERPOINT, in Music, the combining and modulating consonant sounds.

COUNTERPOISE, any weight which, placed in opposition to another weight, produces an equilibrium, but it is more commonly used to denote the weight used in the Roman balance or steelyard.

COUNTERSCARP, in Fortification, the exterior slope of the ditch, though it is often taken for the covered way and glacis. *Angle of the Counterscarp*, is that made by its two sides meeting before the middle of the curtain.

COUNTERTENOR, in Music, high tenor; a term applied to the highest natural male voice.

COUNT-WHEEL, in the striking part of a clock, is that which moves round once in 12 or 24 hours.

COUP-DE-MAIN, in Military affairs, implies a desperate resolution in small expeditions of surprise; or the attacking a place sword in hand.

COUPURE, in Fortification, passages sometimes cut through the glacis, of about twelve or fifteen feet broad, in the re-entering angle of the covert way, to facilitate the sallies of the besieged.

COURSE, in Navigation, the point of the compass, or horizon, which the ship steers on, or the angle which the rhumb line on which it sails makes with the meridian; and is sometimes reckoned in degrees, and sometimes in points and quarter points of the compass.

COURSING, among sportsmen, is of three sorts, *viz.* at the deer, at the hare, and at the fox. These coursings are with greyhounds; for the deer there are two sorts of coursings, the one with the padduck, the other either in the forest or purlieu.

COURT, a place for the administration of justice. The most general division of our courts is into those of record, and those which are not; those of record are divided into supreme and superior or inferior. The supreme court of this kingdom is the high court of parliament, which has an absolute power to make new laws, and to repeal and alter old ones. Superior courts of record are the House of Lords, the Chancery, King's Bench, Common Pleas, and Exchequer; the less principal are those held by commission of gaol delivery, oyer and terminer, assize, nisi prius, &c. The inferior courts of record are corporation courts, courts leet, the sheriff's torn, &c. Courts not of record are the courts baron, county courts, hundred courts, &c.; also the admiralty and ecclesiastical courts, which derive their authority from the crown, and are subject to the control of the king's temporal courts, if they exceed their jurisdiction.

COURT BARON, a court held by every lord of a manor within the same; and if the number of suitors should so fail as not to leave enough to make a jury or homage, that is, two tenants at least, the manor is lost. This court may inquire of the death of tenants, of nuisances, waste, trespass, forfeitures, &c. and the punishment is by amercement.

COURT OF CONSCIENCE, in the cities of London, Westminster, and some other places, determines matters in all cases, where the debt or damage is under forty shillings. In some places these courts have power to decide on larger sums.

COVENANT, in Law, the agreement or consent of two or more, by deed in writing, sealed and delivered; whereby either, or one of the parties, promises to the other, that something is done already, or shall be performed afterwards.

COVERT-WAY, or CORRIDOR, in Fortification, a space of ground, level with the field, on the edge of the ditch, three or four fathoms broad, ranging round the half-moons, and other works toward the country.

COVERTURE, in Law, a term applied to a married woman who is under the power of her husband, and therefore incapable of making bargains to the injury of herself or her husband.

COVIN, in Law, a deceitful assent or agreement between two or more, to the prejudice of another.

CRAB, a wooden pillar, somewhat resembling a small capstan, but not furnished with a drum head; instead of which, two, three, or four holes are made one above another, through the middle of its upper end, into which long bars are thrust, whose length is nearly equal to the breadth of the deck. It is employed for the same purposes as the capstan, but not being so convenient, is now generally laid aside, except in rope-walks, &c. The Crab, a machine with three claws, is used to launch ships, and to heave them into the dock, or off the key. *See* CANCER, for the *Celestial Crab.*

CRADLE, a frame placed under the bottom of a ship, in order to conduct her steadily and smoothly into the water when she is to be launched, at which time it supports her weight while she slides down the descent or sloping passage, called the Ways, which are for this purpose daubed with soap or tallow. Cradles are also standing bedsteads made up for the wounded seamen, that they may be more comfortable than it is possible to be in a hammock.—Chidren's wicker cradles need hardly be alluded to; nor does the more fashionable rocking or swing cot require illustration, except to observe, that the principle of suspension is capable of great improvement upon a very simple plan, that of the pendulum, in place of the clumsy method of hanging the cot on a tawdry brass knob, by a piece of wire bent in the form of an equilateral triangle.

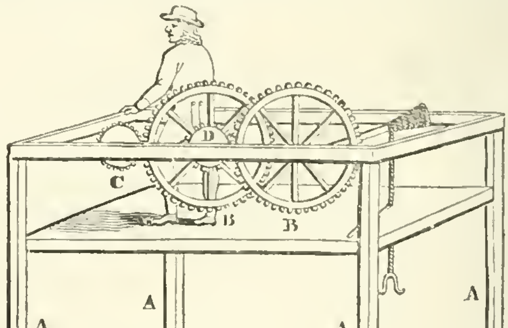
CRAFT, a general name for all sorts of vessels employed to load or discharge merchant ships, or to carry alongside, or return the guns, stores, or provisions of a man-of-war; such are lighters, hoys, barges, &c.

CRAMBE, *Sea Cabbage, Sea Beach Kale,* or *Sea Colewort,* a genus of the siliquosa order, in the tetradynamia class of plants, ranking in the natural method under the 39th order siliquosæ. There are six species, three herbaceous esculents with perennial roots, producing annually large leaves like those of the cabbage, spreading on the ground with yellow flowers. Only one species is a native of Britain, and it grows wild in several parts of the sea-coast. It is propagated by seeds sown in common light earth in autumn or spring. The crambe-fruticosa is a greenhouse plant.

CRAMP, in Medicine, a convulsive contraction of a muscular part of the body, being either natural, as in convulsive constitutions, or accidental, from living in cold places, under ground, &c. It affects all parts indifferently, but the ham, calves, feet, and toes, oftener than the arms and hands. An effectual preventive for cramp in the calves of the legs, which is a most grievous pain, is to stretch out the heel of the leg as far as possible, at the same time drawing up the toes to the body. This will frequently stop the progress of a fit of the cramp after it has commenced; and a person will, after a few times, be able in general to prevent the fit coming on, though its approach be between sleep and waking.

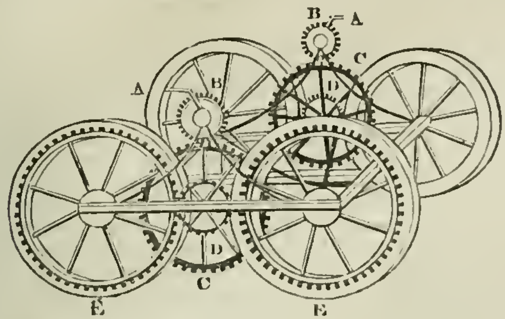
CRANE, THE, a machine used in building, on wharfs, and in warehouses, for raising and lowering huge stones, ponderous weights, packages, bales of goods, &c. has been variously constructed, and will therefore require a few examples.

The *Cellar Crane* we have already noticed. The *Portable Stone Crane for Loading and Unloading Carts*, is mounted on a wooden stage, and is so constructed that it may be taken to pieces. The frame A, A, A, A, is about 10 feet high and 9 feet

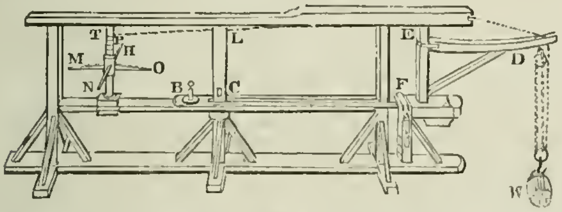


square; the wheels B, B, are of iron, and 3 feet diameter; the pinion D fixed to the axis of the first wheel B is 8 inches in diameter; and the other pinion C is about the same diameter. When stones are suspended to the rope that coils round the barrel, the labourer turns a winch on the axis of the wheel C, and raises or lowers the weight according to the direction in which he turns it.

Gottlieb's Carriage Crane.—This machine, which is useful for carrying large stones where carts and horses cannot be easily obtained, consists of two sorts of crane wheels applied to the two sets of wheels belonging to the carriage, so that two men, one acting at each winch A, A, give motion to the loaded carriage. The pinion B, 6 inches in diameter, turns the wheel C, 3 feet in diameter. The wheel C gives motion to the pinion D, one foot in diameter, which works into two wheels E, E, 3 feet 6 inches diameter, and are fixed on the wheels of the carriage.

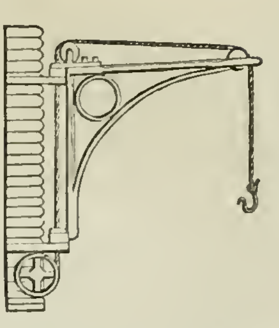


Andrew's Weighing Crane, weighs the body at the time that it raises it. The weight W is elevated by means of the levers M, H, O, N, which coils the rope T R round the barrel P. The jib E D stands on a horizontal beam, moveable in a vertical plane round the centre F A, and the distance of the upright beam E from the centre of motion A, is ½ of B F. The weight of the bulk W is then ascertained by the weight at B, which keeps it in equilibrio. The piece of wood C projects from the vertical beam C L, in order to prevent the beam from rising too high.



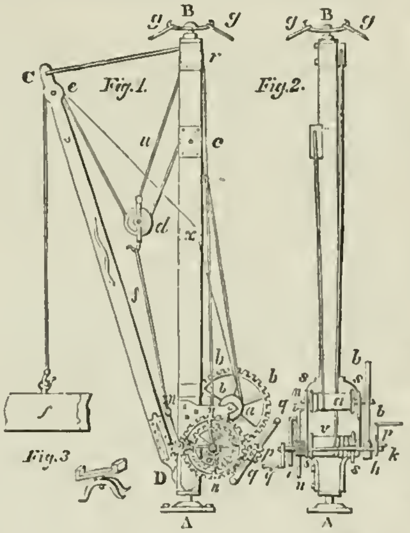
Ferguson's Crane has three trundles, with different numbers of staves, that may be applied to the cogs of a horizontal wheel with an upright axle; round which is coiled the rope that draws up the weight. This wheel has 96 cogs; the largest trundle 24 staves, the next 12, and the smallest 6, so that the largest revolves 4 times for one revolution of the wheel; the next 8, and the smallest 16. A winch is occasionally fixed on the axis of either of these trundles, for turning it; and is applied to the one or the other according as the weight to be raised is smaller or larger. While this is drawing up, the ratch-teeth of a wheel slip round below a catch that falls into them, prevents the crane from turning backwards, and detains the weight in any part of its ascent, if the man who works at the winch should accidentally quit his hold, or wish to rest himself before the weight is completely raised. Making a due allowance for friction, a man may raise by such a crane from three times to twelve times as much in weight as would balance his effort at the winch; *viz.* from 90 to 360 lbs. taking the average labour.

Bramah's Jib for Cranes.—The nature of this invention may be easily understood from a bare inspection of the figure, which represents a jib attached to the wall of a warehouse. The jib turns on a perforated axis or pillar. The rope by which the weight is raised, after passing over two pulleys, goes through the perforated axis, and is conducted over another pulley to the barrel of the crane, which is not represented in the figure. In jibs of the common construction, which turn in two solid gudgeons, the rope passes over the upper gudgeon, and is confined between two vertical rollers; but the bending of the rope occasions a great deal of friction, and produces a constant effort to bring the arm of the jib into a position parallel to the inner part of the rope. Cranes of this construction are in common use in warehouses in London, and all parts of the country.



Watt's Jib Crane.—Fig 1 is a side view of the crane, shewing the jib; fig. 2 is a back view, shewing the chain, barrels, and edges of the wheels and pinions; fig. 3 is a fulcrum, used in shifting the crane from place to place. The same reference-letters are put to the same points in both figures.

A B is the upright shaft. It is made of a firbalk 12½ inches square, and 23 feet long. Its lower pivot turns in a cross step at A, and its upper one in a cross at B, supported by four gy-ropes, two of which *g g* are shewn in each figure. Immediately above the pivot are two strong plates of cast iron, bolted to the opposite sides, for receiving the bolt at D, upon which the jib turns. Above these, the shaft is fortified by side pieces, till it has a breadth of 26½ inches, where are fastened the cast-iron cheeks *s s*, of which an edge view is given in fig. 2, and which may be traced behind the wheels *i i* and *n n*, in fig. 1. Four brass beds, covered by cap squares of the same metal, are placed in these checks, for receiving the axles of the wheels and pinions. Two strong cast-iron blocks, with grooved pulleys for the chains, are placed at *c* and *r*, upon opposite sides of the shaft.



C D is the jib, formed of two oak battens, 7½ inches by 2¾ at their lower extremities, and 5½ by 2½ at their upper. They are 3 inches asunder at the lower extremity; where, and at the serpentine plate at the middle, they are separated by blocks, and they meet within a few feet of the upper extremity. The extremity D is fortified by two strong plates of cast-iron, which go withinside the plates in the shaft, and receive the axle-bolt; and the other two plates at the extremity C, contain a grooved pulley, shewn by the dotted circle at *c*, and a bolt for fastening the chain C *r*. The length of the jib from the axle-bolt at D to the centre of the pulley *e*, is 20½ feet.

There are two chain-barrels. The barrel *a* raises or lowers the weight *f*, by means of the chain which passes over the pulleys *c*, *d*, *e*; and the barrel *v* contracts or expands the jib, by means of the chain which passes over the pulley *r*. The crane-barrel *a* is about 9½ inches in diameter, and the jib-barrel *v* about 8 inches; and the chains for both are made with circular links from five-eighths inch iron rod. These barrels may be either both worked at the same time, in the same or in opposite directions, or either of them may be worked separately. The jib-barrel has a single power, produced by the pinion *p*, of 10 leaves, and 5½ inches diameter, acting on the wheel *n n*, of 76 teeth, and 36¾ inches diameter. The pinion *p* is moved by the winches *q q*, which have a lever power of 16 inches. The jib-barrel may be locked by pushing a moveable bolt, till it bear against an arm of the wheel *n n*. The single power of the crane-barrel is obtained by placing winches (16 inch) on the squares *k k* (fig. 2), which terminate an arbor passing through the centre of the jib-barrel, and having on its one end the wheel *i i*, and on its other the pinion *h* (fig. 2). The pinion *h* (5⅛ inches diameter, 9 leaves,) moves the wheel *b b*, which is fastened on the arbor of the crane-barrel, and has 36¾ inches diameter, and 76 teeth.

The double power is obtained by turning the pinion *l* by means of the winch *m* (16 inches), and one on the opposite end of the same arbor. The pinion *l* is 8¼ inches diameter, and has 16 leaves, and the wheel *i i*, which it turns, is 32 inches diameter, and has 66 teeth. The check-block *d* is a single pulley kept in its place by the chains *t*, *u*, and is necessary for securing the action of the jib at all angles of elevation, by preserving the angle D *e d*, always smaller than the angle D *e f*, it being obvious, from the doctrine of the resolution of forces, that when these angles are exactly equal, the point of the jib will be in equilibrio; but that when they are unequal, it will have a tendency to move in the direction of the greater angle. When D *e f* is the greater, the jib can be prevented from falling down by the jib-chain C *r*; but if D *e d* were the greater, there is nothing to prevent it from rising till it would come in contact with A B.

The fulcrum (fig. 3) is, when the crane is to be shifted, placed near the axle-bolt of the jib at D; then the jib is lowered, and acts as a lever in taking the weight of the crane off the cross-foot. The cross-head of the fulcrum moves on a pivot in the tripod, and by means of it, and easing off two of the gy-ropes while the opposite ones are hauled in, the crane is moved along in an upright position.—The total cost of such a crane is about £70; and the parts are so constructed that it may be used for many years without requiring the smallest expense for repairs.

The power of the jib-barrel, without making allowance for friction, is about 26½, when the winch is in an horizontal position; but as the resistance of the weight varies with every change in the elevation of the jib, it is not possible to calculate the power which would be necessary to move it with any given weight. The more that the jib is elevated, the less power is required. The single power of the crane-barrel, without making allowance for friction, is about 24½, and the double power about 101. It is not possible to determine the friction exactly, because it varies both with the weight and the position of the chains, being more as the weight is greater, and the angles formed by the chains less. But the result of experiments made with a load of one ton, and the jib at an angle of about 45 degrees, were as follows:—

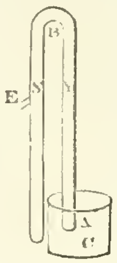
Single Power.	lbs.
Power required to suspend a ton, by calculation, about	91
Ditto, by trial, with check block, about	154
Total friction,..................................	63
Ditto, without check-block,........................	128
Friction on check-block, ...	26

Double Power.	
Power required to suspend a ton, by calculation, about	22
Ditto, by trial, with check-block, about	44
Total friction,..................................	22
Ditto, without check-block,........................	38
Friction on check-block,..........................	6

Hence the whole friction on the single power is equal to about two-fifths, and that on the double power about one-half of the power employed; and the friction upon the check-block nearly one-seventh of the power in both cases. The small arc, however, over which the winch can traverse, without a great alteration of power, when trial is made by weight, suspended from the winch, and the great strain produced by a pressure of two tons on the machine, render such experiments but very loose approximations.*

As a building crane, this possesses many advantages over those commonly in use, from the complete command it has over every inch of space within the range of the jib. The common building crane, with a fixed jib and moveable truck, commands indeed the same angular range; but then the truck cannot, without an additional power, be removed farther from the shaft, after the crane is loaded, and thus its operation is confined. The common crane is also much less portable, and cannot be moved even for the shortest distance without being taken down—an operation which costs a good deal of time and labour. Indeed, in as far as portability, power, and the complete command of a given space are concerned, this crane is decidedly superior to every other; and in every case of building with large stones, where gy-ropes can be used, it deserves the preference. Where gy-ropes cannot be used, Mr. Watt's balance, or counterpoise crane, is equally applicable and excellent. Indeed, the whole machines invented by this ingenious mechanic, while employed at the construction of the Bell-Rock Lighthouse, form a series of applications of the mechanical powers highly unique and valuable; and shew of how much consequence it would be to the arts and to society, were mechanical genius in common workmen duly appreciated and regarded.—*Mech. Mag.* vol. ii. No. 54.

Crane is also a popular name for a syphon employed in drawing off liquors. This crane or syphon is nothing else than a bent tube, as A B G. If the shorter end A B be immersed in a vessel of water or other fluid, C, then by applying the mouth to the end G, and sucking till the liquor arrives there, it will continue to flow out at the end G, as long as that end is lower than the surface of the fluid in the vessel C. If there be a mouth-piece at E, then sucking at that mouth-piece (while the end G is stopt with a finger or otherwise,) will make the fluid flow when the obstruction is taken away from G. When the fluid has begun to flow, the hole at E must be stopped up, or the fluid will flow no longer than till the surface in the vessel be as low as E. The reason of the motion of the liquor in the syphon is this:—The perpendicular height of the column B G being greater than B A, the pressure of the atmosphere being the same at both orifices, supposing them of equal area, therefore the weight at G will cause the fluid to flow out there, while the pressure of the atmosphere will force more liquor up at the end A, and thus the motion will continue so long as there is any fluid in the vessel, provided the end G is lower than the end A of the syphon. Hence it is evident, that the height from the surface of the fluid to the top B must not exceed the altitude of a column of the fluid whose weight is equal to the pressure of the atmosphere on the same base, or the fluid may be drawn up by sucking at the aperture E, which must be closed as soon as the liquor is made to run. Many improvements have been made on this instrument, which it is not our purpose to repeat here.



CRANIOLOGY, is a science by which it is attempted, from the external shape of the skull, to form an opinion of the animal propensities and intellectual powers. A few words will serve to shew the principle on which it is founded. That the intellectual powers and animal propensities have their seat in the brain, has generally been admitted, but according to the doctrines of craniology, of which Drs. Gall and Spurzheim have been the chief propagators, these do not depend on the brain generally, but each distinct faculty and propensity has its seat in a particular portion of the brain. If therefore any part of the brain be unusually large in any individual, that individual will be distinguished for an extraordinary degree of the intellectual faculty, or animal propensity, of which the enlarged portion of the brain is the seat. If, on the other hand, any portion of the brain be unusually small, he will be remarkable for a deficiency of the particular faculty or propensity of which the diminished portion is the seat. As the enlargement of any portion of the brain will produce an elevation of the skull, particularly in infancy, when the bones are soft, the craniologists endeavour, by observing the protuberances of the skull, to form a judgment of any individual's intellectual powers or animal propensities. Drs. Gall and Spurzheim have attempted to fix, from observation of a number of remarkable individuals, what portions of the brain are the seat of the different faculties and propensities, and have accordingly divided the surface of the cranium into portions like the counties in a map of England. But the whole of this appears to the editor and author of this Dictionary absolute nonsense.

---

* Still it is evident, that could the check-block be dispensed with, the power of the crane would be very much increased. Now, if the point of the jib did not require to be very much raised, the block might be dispensed with, by giving the pulley *c* a situation lower down to the shaft, such as *x*; but if it were brought very low, the chain would not coil properly on the barrel. This might, however, be obviated, by placing the crane-barrel on the other side of the shaft, and bringing the chain down the back of the jib from the pulley *e*, without passing it over any other pulley whatever. As, however, the placing of the barrel in this situation would prevent the jib from being brought so near to the shaft as it can be with the check-block; and as, notwithstanding the friction on the block, the crane is sufficiently powerful, the alteration is a matter of less importance.

Such a system as this ought to have for its support observations on a very great number of individuals, and the cases which bear against it, as well as for it, ought to be candidly stated. The small number of cases, under each head in Dr. Spurzheim's work, is very remarkable, and the blunders made by professed craniologists, who have attempted to give the character of individuals whose skulls they have examined, and who were unknown to them, have much tended to destroy all faith in the accuracy of its conclusions. It also deserves to be noticed, that there are external elevations of the skull, where there are no corresponding internal elevations of the brain. The ridicule to which the subject has been exposed, has produced a great zeal in its professors, and whilst that continues, we may expect them to trumpet forth cases in their favour, and to say little of such as do not tend to bring credit to their favourite science.

CRANK, in Mechanics, a square piece projecting from a spindle, serving by its rotation to raise and fall the pistons of engines. It also denotes the iron support for a lantern, and the iron made fast to the stock of a bell.

CRAPE, a light stuff resembling gauze, made of raw silk gummed and twisted on the mill, and woven without crossing.

CRATÆGUS, *Wild Service Tree, Hawthorn*, &c. a genus of the digynia order, in the icosandria class of plants, ranking in the natural method under the 36th order, pomaceæ. There are 28 species, among which the wild service, or maple-leaved service, a large tree that grows in England, Germany, Switzerland, and France, is valuable for its timber.

CRATER, *the Cup*, is an ancient constellation, sufficiently typical by its place between the meridian intersecting the Lion and Virgin, of its use at the summer solstice, when Taurus opened the year. The fable which attributes this goblet to Bacchus, is a finely allegorized symbol of Noah's planting the vine; and the translation of the cup to a place in the heavens corresponding with the primitive solstice of astronomy, gives some support to the hypothesis that assigns to Bacchus an Asiatic origin.—The boundaries and contents of this constellation are: north by Virgo, east by Corvus, south and west by Hydra. There are 13 stars in this asterism, of which θ, ϵ, δ, γ, ζ, and η, form the demi-circumference of the lip. α *Alkes* to the south, and β, determine the bottom of the vessel.

CRAX, *the Curassou*, a genus of birds belonging to the order of galinæ, of which there are five species, natives of India, Africa, and South America.

CRAYON, a general name for a coloured stone, earth, or other substance, used in designing or painting in pastel, whether reduced to a paste, or used in their primitive consistence. In this last manner red crayons are made of blood stone or red chalk, black ones of charcoal and black lead, &c. Crayons of all other colours are compositions of earth.

CRAYON PAINTING, requires, in many respects, a treatment different from that in oil, because all colours used dry are of a warmer complexion than when wet with oils, for which reason, to produce a rich picture, a greater portion of what are termed *cooling tints*, must be applied in crayon painting, than would be proper in oil. The paper for crayon painting should be strong blue or gray, and free from knots. The artist should work sitting with the crayons in his lap, and the part of the picture he is painting should be rather below his face. The windows should be darkened to the height of six feet from the floor, and the subject to be painted so placed that the light may fall with advantage on the face.

CREPITATION, or Detonation, in Chemistry, the noise made by some salts over the fire in calcination. In Surgery, the sound made by the ends of bones when the limb is moved, that the existence of a fracture may be ascertained.

CREPUSCULUM, in Astronomy, twilight; the time from the first dawn or appearance of the morning to the rising sun; and again, between the setting of the sun and the last remains of day. Pappus derives the word from *creperus*; which, he says, anciently signified uncertain, doubtful, *viz.* a dubious light. The crepusculum is usually computed to begin and end when the sun is about 18 degrees below the horizon; for then the stars of the sixth magnitude disappear in the morning, and appear in the evening. It is of longer duration in the solstices than in the equinoxes, and longer in an oblique than in a right sphere. The crepuscula are occasioned by the sun's rays refracted in our atmosphere, and reflected from the particles thereof to the eye. *See* Twilight.

CRESCENT, in Heraldry, a bearing in the form of a new moon.

CRESCENTIA, *the Calabash Tree*, a genus of the angiospermia order, in the didynamia class of plants, ranking in the natural method under the 25th order, putamineæ. There are two species; 1. The cujete, with long narrow leaves, and a large oval fruit, is a native of the West India islands. Its height is 20 or 30 feet, and the flowers, which are of a yellowish green colour, striped and spotted with brown, are succeeded by large fruit of a spherical or oval form. 2. The cucurbitana or broad-leaved calabash, rises to the height of 15 or 20 feet; the flowers are smaller than those of the preceding, and of a deeper yellow. The fruit is round or oval. The shells of both are made use of for drinking cups, punch-bowls, and other purposes, some of them will hold fifteen pints of water. The wood of the tree is made into stools and other furniture.

CREST, in Armoury, the top part of the helmet, generally ornamental. In Heraldry, it is that part of the casque or helmet next the mantle.

CRITHMUM, *Samphire*, a genus of the digynia order, in the pentandria class of plants, ranking in the natural method under the 45th order, umbellatæ. There are three species, the principal of which is the maritimum or common marine samphire, which has a fibrous penetrating root; thick succulent branching stalks, rising two feet high; fleshy leaves, with round yellow flowers. It grows on the sea-coast among gravel and rocks. The principal use of it is as a pickle.

CROCUS, *Saffron*, a genus of the monogynia order, in the triandria class of plants, ranking in the natural method under the 6th order, ensatæ. There are two species, and of each several varieties.

CROISADE, Crusade, or Cruzado, a name given to the expeditions of the Christians against the Infidels, for the conquest of Palestine; so called, because those who engaged in the undertaking wore a cross on their clothes, and bore one on their standard. This expedition was also called the holy war, to which people flocked in great numbers out of pure devotion, the pope's bulls and the preaching of the priests of those days making it a point of conscience. The several nations engaged in the holy war, were distinguished by the different colours of their crosses: the English wore white, the French red, the Flemish green, the Germans black, and the Italians yellow. From this enterprise several orders of knighthood took their rise. They reckon eight croisades for the conquest of the Holy Land; the first begun in the year 1095, at the solicitation of the Greek emperor and the patriarch of Jerusalem.

CROMLECH, in British antiquities, huge broad flat stones, raised upon other stones set up on end. They are common in Anglesea, and are supposed by some persons to have been tombs, though others imagine that they were altars for religious services.

CROSS, an instrument used in surveying, for the purpose of raising perpendiculars. It consists merely of two pair of sights set at right angles to each other, mounted on a staff, of a convenient height for use. The method of using it is, to get in a line with one pair of sights, the marks at the extremities of the base line, or that on which the perpendicular is to be raised, and through the other pair the mark or object to which the perpendicular is to be measured; and the line or distance between the foot of the staff and the object will be the perpendicular required. *See* Surveying.

Cross-*Multiplication*. *See* Duodecimals.

Cross-*Staff*, or *Fore-Staff*, an instrument formerly used by mariners, for taking the meridian altitude of the sun or stars.

CROTALUS, *Rattle-Snake*, a genus belonging to the order of amphibia serpentes. The banded rattle-snake is from three to five feet long, of a yellowish brown colour, marked throughout with transverse streaks or spots of deep brown, and from the head down the neck run two or three stripes of the same colour; the head is large, flat, and scaly; the rest of the upper part covered with large oval scales; the under parts are of a dingy colour, marked with numerous freckles; at the end of the tail is the rattle, consisting of several horny processes, which the animal elevates and shakes when irritated or disturbed. The rattle-snake lives upon frogs, squirrels, and birds. The two last it catches in an extraordinary manner, placing itself under the tree where they rest, and by shaking the rattle awakens them; they then flutter and jump about from spray to spray, till, tired and frightened, they fall into the mouth of the enemy beneath. Rattle-snakes abound in North and South America. Their bite is fatal, but they never attack a person without provocation. The striped rattle-snake, of a deep brown colour above, with pale yellow streaks forming large lozenges down the back, is also a native of America, and equally venomous. The wood rattle-snake is of a lighter colour than the two preceding. And the military rattle-snake, of a gray-brown, shaded on the back with red and marked with black spots, is smaller than the other kinds.

CROTCHET, in Music, a note or character of time marked thus, ♩, equal to half a minim and double a quaver.

CROTCHETS, marks enclosing a word or sentence to be distinguished from the rest, thus, [ ] or ( ).

CROTON, *Wild Ricinus*, which grows naturally in the south of France, and from it is made the turnsole used for colouring wines and jellies. This is made of the juice lodged between the empalement and the seeds; and if rubbed on cloths at first appears green, but soon changes to a purple. If these cloths are put into water, they will dye it of a claret colour. The rags thus dyed are brought to this country, and sold under the name of turnsole.

CROW, in Mechanics, a kind of iron lever, sharp at one end and a claw at the other, used for heaving or pushing great weights.

CROWN, in Astronomy. *See* Corona.

CROWN, in Geometry, a plane ring, included between two concentric perimeters, generated by the motion of part of a right line round the centre, to which the moving part is not contiguous. The area of a crown is had by multiplying its breadth by the length of the middle periphery; for a series of terms in arithmetical progression being $n \times \frac{a + w}{2}$, *i. e.* the sum of the first and last multiplied by half the number of terms, the middle terms must be $\frac{a + w}{2}$, therefore, that multiplied by the breadth or sum of all the two terms will give the crown.

Crown, is also a silver coinage of England, and many other countries; the English crown is equal in value to 5 shillings; the Danish crown is 2*s*. 8¼*d*.; German, 4*s*. 7½*d*.; French, 4*s*. 9¼*d*. sterling.

CROWN-WHEEL of a Watch, the upper wheel, which, by its motion, drives the balance. In royal pendulums it is called the swing wheel.

CROWN-WORK, in Fortification, an outwork having a large gorge, and two long sides terminating towards the field in two demi-bastions. It is intended to enclose a rising ground, or to cover an entrenchment.

CROW'S BILL, a surgical instrument for extracting balls and other substances from wounds.

CROW'S FEET, in Military affairs, machines of iron having four points so made that whatever way they fall there is a point upwards; these are thrown upon breaches, or in passes, to lame the horses of the enemy.

CRUCIBLE, a chemical vessel made of earth, and so tempered as to endure the strongest heat.

CRUSTACEOUS Fish, are those covered with shells, consisting of several pieces or scales, as crabs, lobsters, &c.

CRUX, *the Cross*, is an asterism containing five stars, *viz.* one of the 1st magnitude, two of the 2d, one of the 3d, and one of the 4th. Four of these stars are in the form of a cross, and the most northerly and southerly are always in a line with the south pole. They are, therefore, the *Pointers* for discerning, in the southern hemisphere, the Antarctic pole. α, of the 1st magnitude, in the foot of the Cross, has 12 ho. 16′ 48″ right ascension in Time (*Ann. Var.* 3″.23), and 62° 6′ 49″ south declination, (*Ann. Var.* + 20″.00.) γ, of the 2d magnitude, in the top of the Cross, has 12 ho. 21′ 20″, (*Ann. Var.* 3″.24), and 56° 6′ 41″ south declination, (*Ann. Var.* + 19″.97.) β, of the 2d magnitude, in the arm, has 12 ho. 37′ 24″, (*Ann. Var.* 3″.41,) and 58° 42′ 53″ south declination, (*Ann. Var.* + 19″.80.)

CRYSTAL, in Natural History, the name of a large class of fossils, hard, pellucid, and colourless.

CRYSTALLINE Heavens, in the old Astronomy, two orbs imagined between the primum mobile and the firmament, in the Ptolemaic system, in which the heavens are supposed solid, and only susceptible of a single motion. These orbs are said to have been introduced by Alphonsus, in order to explain what the ancients called the motion of trepidation or titubation.

CRYSTALLIZATION. When fluid substances become solid they frequently assume regular polyhedral forms, which are called *crystals*, and the bodies which do so are said to be susceptible of crystallization. Many minerals are found which are thus arranged into regular forms.

To enable the particles of bodies to assume that regular form which crystals exhibit, they must have freedom of motion; and, accordingly, the first step is to confer a liquid or aëriform state, by solution in water. When common salt is dissolved in water, the particles will be too far asunder to exert reciprocal attraction; in other words, they will be more powerfully attracted by the water than by each other. If we now get rid of a portion of the water by evaporation, the saline particles will gradually approach each other, and will aggregate according to certain laws, producing a regular solid of a cubic form. If the process be slowly conducted, the particles unite with great regularity; if hurried, the crystals are irregular and confused.

There are certain bodies which may be liquefied by heat, and during slow cooling may be made to crystallize. This is the case with many of the metals, and with sulphur. Some other substances, when heated, readily assume the state of vapour, and during condensation present regular crystalline forms, such as iodine, benzoic acid, camphor, &c.

The hardness, brilliancy, and transparency of crystals often depend upon their containing water, which sometimes exists in them in large quantities.

Thus sulphate of soda, in the state of crystals, contains more than half its weight. This is called water of crystallization. Some salts part with it by a simple exposure to dry air, when they are said to effloresce; but there are other salts which deliquesce, or attract water from the atmosphere.

Crystallization is accelerated by introducing into the solution a nucleus, or solid body, upon which the process begins, and manufacturers often avail themselves of this circumstance.

A strong saline solution excluded from the air will frequently crystallize the instant that air is admitted, a circumstance referred to atmospheric pressure. In other cases agitation produces the same effect. The presence of light also influences the process of crystallization. Thus the crystals collected in camphor bottles in druggists' windows, are always most copious upon the surface exposed to the light. Crystallized bodies affect one form in preference to others. The fluor spar of Derbyshire crystallizes in cubes; so does common salt; nitre in the form of a six-sided prism; and sulphate of magnesia in that of a four-sided prism. These forms are liable to vary. Fluor spar and salt crystallize sometimes in the form of octahedra: and there are so many forms of carbonate of lime, that it is difficult to select that which most commonly occurs.

Rome de Lisle referred these variations of form to certain transactions of an invariable primitive nucleus. Bergman suspected the existence of a primitive nucleus in all primitive bodies. When Haüy entered this field of inquiry, he not only corroborated the opinions of Bergman, but traced with much success the laws of crystallization, and pointed out the mode of transition from primitive to secondary figures.

Dr. Wollaston supposed the primitive particles to be of a spherical form, and that their mutual attraction produces crystallization in the various regular forms in which it appears.—When alum is dissolved in water, various figures appear upon it. Those who are in the habit of cutting and polishing certain gems, have long known that they only afford smooth surfaces when broken in one direction.—*Watkin's Cyclopædia.*

CRYSTALLOGRAPHY, the science which attempts to explain the laws by which crystallization takes place.

CRYSTALLIZING *the Surface of Tin and other Metals.*—The process of giving the new ornamental surface on metals or metallic compositions, consists in employing those acids and saline compounds and substances which chemically act upon tin, and which, when employed in the manner to be stated, presently give to the metal or metallic compositions to which they are applied, the appearance of a crystalline surface variously modified; to produce this effect, the metal or metallic composition ought to be previously tinned or covered with a thin coat of tin. If the metal be pure tin, it requires no previous preparation. All grease remaining on the tinned surface, in consequence of tinning, is to be taken off with a solution of potash, soap, or any alkaline substances. The tin or tinned surface should then be washed with pure water, dried, and heated to a temperature which the hand can bear; when the surface has thus been cleaned and heated, any of the acids which act upon tin, or the vapours of these, will cause the desired appearance of crystallization, but preference is given to the following composition, which may conveniently be laid over with a brush or a sponge: take one part by measure of sulphuric acid, dilute it with five parts of water. Take also one part of nitric acid, and dilute it with an equal bulk of water, and keep each of the mixtures separate; then take ten parts of the sulphuric acid, dilute it in the manner before stated, and mix it with one part of the diluted nitric acid, and then apply this mixed acid to the tin, or to the tinned surface, with a pencil or sponge, as above directed, and repeat the application of the said composition for several times successively, or until the result you expect proves satisfactory: when this has been done, the crystalline surface may be covered with a varnish or japan, more or less transparent and colourless, or coloured; the whole must now be polished.

CUBATURE, is the finding the solid content of any proposed body, the same as quadrature signifies the finding the superficial area.

CUBE, or HEXAHEDRON, a solid regular body, consisting of six equal square sides. It is supposed to be generated by the motion of a square plane along a line equal and perpendicular to one of its sides.

To determine the Surface and Solidity of a Cube.—Multiply one side by itself, which will give one square; this multiplied by 6 will give the whole surface. Also, multiply one side twice by itself, that is, cube it, and that will give the solid content required.

CUBE, *Duplication of the*, is the finding of the side of a cube that shall double in solidity a given cube. It cannot be done geometrically, as it requires the solution of a cubic equation, or the finding two mean proportionals. Let a be the side of the given cube, and z that of the double one, then $z^3 = 2a^3$, or $a^2 : z^2 :: z : 2a$, therefore, if a and z be the first and second terms of a set of continued proportionals, then $a^2 : z^2$ is the ratio of the square of the first to that of the second, which is the same as the ratio of the first term to the third, or the second to the fourth, or of z to $2a$; therefore z being the second term, $2a$ will be the fourth; so that z, the side of the cube sought, is the second of four terms in continued proportion; the first and fourth being a and $2a$, *i. e.* the side of the double cube is the first of the two mean proportionals between a and $2a$.

CUBEB, POWDER OF, though not yet enrolled in the Pharmacopœia of London, is an article much used by our medical practitioners, to reduce inflammations of the pudenda, attended with the discharge of a mucus. This disease, sometimes mistaken for a venereal affection, is perfectly local, and may be easily cured by taking at night and morning a small portion of the powder of cubeb; thus, half an ounce of the powder made up into twelve parcels, will make doses for six days, during which time the parts affected may be well syringed with warm water and milk; or about 20 drops of port wine thrown into a glass of lukewarm water, makes perhaps a more efficacious wash. If the inflammation is not reduced in a week, the applications should be continued till the discharge entirely disappears.

CUBEBS, the *Cubeba* of Medicine, is a small dried fruit, resembling pepper, brought from Java.

CUBES, or CUBE NUMBERS, in Arithmetic, and the *Theory of Numbers*, are those whose cube root is a complete integer; or they are numbers produced by multiplying a given number twice into itself, or by the multiplication of three equal factors, thus, $1 \times 1 \times 1 = 1$; $2 \times 2 \times 2 = 8$; $3 \times 3 \times 3 = 27$; $4 \times 4 \times 4 = 64$, &c. are cube numbers.

To find the Cube Root of a given Number.—1st Method. Separate the given number into periods of three figures each, by putting a point over the place of units, another over the place of thousands, and so on over every third figure, to the left hand in integers, and to the right in decimals; and then find the nearest cube root of the first period, and set it in the quotient. 2. Subtract the cube of the figure of the root thus found, from the first period, to the left hand, and annex the following period to the remainder for a dividend. 3. Divide this dividend by 3 times the square of the figure of the root above determined, and the first figure of the quotient will be the second figure of the root. 4. Subtract the cube of these two figures of the root from the first two periods on the left, and to the remainder annex the following period, for a new dividend, which divide as before; and so on till the whole is finished. And finally, point off as many figures for integers as there are periods of integers in the proposed number.

Example. Required the cube root of 41278·242816.

$$\begin{array}{rcl}
 & & 4\dot{1}27\dot{8}\cdot24\dot{2}81\dot{6}\,(34\cdot56\text{ root}\\
3^3 & = & 27\\
3^2 \times 3 & = & 27)\,14278\,(4\text{ 2d figure of the root}\\
 & & 41278\quad\text{1st two periods}\\
34^3 & = & 39304\\
34^2 \times 3 & = & 3168)\,1974\cdot242\,(5,\text{ 3d figure}\\
 & & 41278\cdot242\quad\text{1st three periods}\\
345^3 & = & 41063\cdot625\\
345^2 \times 3 & = & 357075)\,214\cdot617816\,(6\text{-4th figure}
\end{array}$$

and thus the operation may be carried on till the root be obtained to any degree of accuracy required. This method, however, is extremely laborious, and is seldom or never employed, as other methods have been found in which the approximation is carried on much more rapidly.

2d Method. Find by trials the nearest rational cube to the given number, and call it the assumed cube. Then, as double the assumed cube added to the given number, is to double the given number added to the assumed cube, so is the root of the assumed cube to the required root, nearly. Or, as the first sum is to the difference of the given number and assumed cube, so is the assumed root to the difference of the roots, nearly.—By taking the cube of the root thus found, for the assumed cube, and repeating the operation, the root will be had to a still greater degree of exactness.

3d Method. Point off the given number in periods of three figures each, reckoning from the units' place: then find the cube of the first period on the right hand, set it down under that period, and subtract the one from the other, and to the remainder bring down the next period. To find the cube of this period, square the quotient, and multiply the product by

300 for a new divisor. Find how often this divisor is contained in the dividend, set it down, and bring down the two first periods in the dividend; cube the quotient figures, place their value under the original dividend periods, and subtract as before, and proceed thus till all the dividend is brought down.

Example. 14886936 is the number whose cube root is sought.

$$
\begin{array}{rl}
 & 14{\cdot}886{\cdot}936\,(\,246 \\
2 \times 2 \times 2 = \big) & 8 \\
\hline
 & 6{\cdot}886 \\
\hline
2 \times 2 \times 300 = 1200\,\big) & 16886 \\
24 \times 24 \times 24 = & 13824 \\
\hline
 & 3062936 \\
\hline
24 \times 24 \times 300 = 172800\,\big) & 14{\cdot}886\,936 \\
246 \times 246 \times 246 = & 14{\cdot}886{\cdot}936 \\
\hline
\end{array}
$$

CUBICAL Equation, in Algebra, one whose highest power consists of three dimensions, as $x^3 = a^3 - b^3$, or $x^3 + r\,x^2 = b^6$, &c.

CUBIT, a measure of length equal to a man's arm from the elbow to the extremity of the fingers. Dr. Arbuthnot states the English cubit at 18 inches, the Roman at 1 foot 5·406 inches, and the Hebrew at 1 foot 9·888 inches.

CUCULUS, *the Cuckoo*, a genus of birds belonging to the order of picæ. The cuckoo appears in the spring, and takes its departure early in July. Some of these birds, however, have been found to winter in this island, taking up their abode in hollow trees, where they have lain in a torpid state. The cuckoo does not rear her own offspring, but selects the nest of some other bird, particularly that of the hedge-sparrow, in which she deposits her eggs. When the sparrow has sat her usual time, and disengaged the young cuckoo from her shell, her own young ones are soon turned out by the intruder, who remains in possession of the nest. There are many more male cuckoos than females, for when five or six have been taken in a trap, not a female has been found among them. Cuckoos may be brought up tame. They will eat bread and milk, fruit, insects, and flesh.

CUCUMBER, *Cucumis*, a genus of the syngenesia order, in the monœcia class of plants, ranking in the natural method under the 34th order, cucurbitaceæ. There are 13 species.

CUCURBIT, in Chemistry, an earthen or glass vessel, so called from its resemblance to a gourd.

CUCURBITA, *the Gourd and Pompion*, a genus of the syngenesia order, in the monœcia class of plants, ranking in the natural method under the 34th order cucurbitaceæ. There are seven species.

CUIRASS, a piece of defensive armour, made of iron plate, well hammered, serving to cover the body from the neck to the girdle, both before and behind.

CULEX, *the Gnat*, a genus of insects of the order of diptera, of which there are seven species. Before they attain the flying state, they are small grubs in the water, after which they turn to chrysalids, then pass to the state of a gnat, and fly into the air.

CULMINATE, to be vertical to, or on the meridian: hence the *culminating point*, is that point of a circle of the sphere that is on the meridian.

CULMINATION, in Astronomy, signifies the passage of any heavenly body over the meridian, or its greatest altitude during its diurnal revolution. In order to find the time of a star's culminating, we must estimate the time nearly, and find the right ascension both of the sun and star corrected for this estimated time; then the difference between these right ascensions, converted into solar time, at the rate of 15 degrees to the hour, gives the time of southing.

CULVERIN, a long slender piece of ordnance or artillery, for carrying a ball to a great distance.

CUMINUM, *Cummin*, a genus of the digynia order, in the pentandria class of plants, ranking in the natural method under the 45th order, umbellatæ. There is only one species which is an annual, that rises nine or ten inches high in warm countries. The flowers are of a pale blue colour; and the seeds have an aromatic taste. These are used in the emplastrum cumini of the Pharmacopœia.

CUNEUS, the Latin term for wedge. *See* Wedge.

CUNITIA, a celebrated lady of Silesia, authoress of a mathematical work entitled "Urania Propitia," published in 1650, in Latin and German; in which are contained various accurate astronomical tables calculated upon Kepler's hypothesis.

CUPEL, a shallow earthen vessel resembling a cup, from which it derives its name, is made of phosphate of lime, or the residue of burned bones rammed into a mould, which gives its figure. This vessel is used in assays wherein the precious metals are fused with lead, which becomes converted into glass, and carries the impure alloy with it.

CUPELLATION, the art of refining gold or silver by means of a cupel. For this purpose another vessel called a muffle is used, within which may be placed one or more cupels.

CUP-GALLS, formed on the leaves of the oak and other trees, resemble a drinking-glass with a cover, which last is flat, and has a small protuberance in the centre.

CUPOLA, in Architecture, a spherical vault, or the round top of the dome of a church.

CUPPING, in Surgery, the operation of applying cupping-glasses, for the local discharge of blood and other humours by the skin.

CUPRESSUS, *the Cypress-tree*, a genus of the monadelphia order, in the monœcia class of plants, ranking in the natural method under the 51st order, coniferæ, of which there are seven species, all raised from seeds, and sometimes from cuttings. The wood of the evergreen cypress is said to resist worms, moths, and putrefaction, and to endure for ages. This tree has also been celebrated as a remedy in pulmonic diseases, from its supposed property of meliorating the air by its balsamic exhalations.

CURATE, the parson, or vicar of a parish, who has the charge or cure of the parishioners' souls; or, a person substituted by the incumbent, to serve his cure in his stead.

CURATOR, among Civilians, one appointed to manage the affairs of minors, or persons incapable of acting for themselves.

CURCULIO, *the weevil*, a genus of insects belonging to the order of coleoptera; and of which there are fifteen species, whose larvæ commit great ravages in corn-lofts, burying themselves in the grain, and entirely devouring the meal. When the insect arrives to its full size it becomes a chrysalis. Other larvæ fix themselves in beans, peas, and lentiles, artichokes, thistles, and the leaves of the elm tree.

CURCUMA, *Turmeric*, a genus of the monogynia order, in the monandria class of plants, ranking in the natural method under the 8th order, scitamineæ, and of which there are three species, that grow naturally in India, whence the roots are brought to Europe, to be used in dyeing yellow: and in medicine as a remedy for the jaundice.

CURFEW, a signal given in cities taken in war, &c. to the inhabitants to go to bed, and advertise the people to secure themselves from the robberies and debaucheries of the night. The most eminent curfew in England, was that established by William the Conqueror, who appointed, under severe penalties, that, at the ringing of a bell, at eight o'clock in the evening, every one should put out their lights and fires, and go to bed: whence to this day, a bell, rung about that time, is called a curfew-bell.

CURING Fish and Bacon.—The following simple and easy mode of preserving mackarel, pilchards, herrings, and sprats, has been proved by experience to answer well. Half fill some water-tight casks or vats, with a brine made from about 28 parts of solid salt to 72 parts of fresh water. Into this brine, the fish, gutted or not, are thrown as fresh as possible, sufficient to nearly fill the vessel. Some moisture will exude from the fish during the pickling, therefore add more salt to saturate it; and as the brine is always weakest in the upper part, a piece of basket work, or lattice work frame, should be provided, to fit inside of the cask or vat, and sunk an inch or two below the surface of the brine, upon which is to be placed some large lumps of solid salt, which will keep fully saturated the whole of the liquor, and keep it so as long as the lumps remain undissolved.

The solidity of these lumps admit of their being applied several times, or as often as the vessels are replenished with fish. The fish are to remain thus immersed in the liquor for five or six days, when they may be taken and packed in large grained salt, as usual. Various sorts of provisions are best preserved by this process, particularly bacon, which is not so liable to become rancid.

CURRANTS, the fruit of a species of grossularia. The white and red sorts are mostly esteemed; the black are employed to flavour English spirits, and counterfeit French brandies. The jelly is reckoned efficacious in sore throats. *Currants* also signify a small kind of grapes brought from Zante and Cephalonia.

CURRENTS, in Navigation, are certain settings of the stream, by which ships are obliged to alter their course, in order to arrive at the destined port. The *setting* of the current is that point of the compass to which the waters run; and the *drift* of the current is the rate it runs per hour. For the method of determining their course and drift, see Robertson's "Navigation," vol. ii. book 7, sect. 8, where the sailing in currents is largely exemplified.

CURRYING, the method of preparing leather with oil, tallow, &c. The skins when they come from the tanner are soaked in water; then stretched on a wooden horse, and being well scraped are put to soak again. While wet they are placed on a hurdle and trampled upon, to make them soft and pliant. In the next place they are soaked in train oil, and when taken out are fastened to large tables. Then the currier with an instrument called a pummel, which is a thick piece of wood, having the under side full of furrows crossing each other, folds, squeezes, and moves them backwards and forwards under the teeth of the instrument, to break their stiffness. This last is called currying: after which operation the skins are either coloured or made white. This last is done by rubbing them with chalk or white lead, and afterwards with pumice-stone. When a skin is to be made black, after it is oiled and dried, the currier passes over it a puff dipt in water impregnated with iron; he next gives it another wetting with a water prepared with soot, vinegar, and gum-arabic. This last operation is repeated till the skin is of a shining black.

CURSITOR, an officer belonging to the chancery, who makes out the original writs. There are twenty-four cursitors allotted to several counties.

CURSOR, a Runner, or Messenger, a small sliding piece of brass, in some mathematical instruments, as the piece of an equinoxial ring-dial, which slides to the day of the month, the point that slides along the beam compass, &c.

CURTAIN, or Curtin, in Fortification, that part of the rampart of a place between the flanks of two bastions, bordered with a parapet five feet high, behind which the soldiers stand to fire upon the covered way and into the moat.

CURTATE Distance, in Astronomy, is the distance of a planet's place from the sun or earth, reduced to the ecliptic; or, the interval between the sun or earth, and that point where a perpendicular, let fall from the planet, meets with the ecliptic.

CURTATION, is the interval between a planet's distance from the sun, and the curtate distance.

CURVATURE of a Line, is its bending or flexure, by which it becomes a curve of any particular form and properties. Thus, the nature of the curvature of the circle is such, that every point in the periphery is equally distant from a point within called the centre; and so the curvature of the same circle is every where the same, but the curvature of all other curves is continually varying. The curvature of a circle is so much the more, as its radius is less, being always reciprocally as the radius and the curvature of other curves is measured by the reciprocal of the radius of a circle, having the same degree of curvature as any curve has, at some certain point. Every curve is bent from its tangent by its curvature, the measure of which is the same as that of the angle of contact formed by the curve and tangent. Now the same tangent is in common to an infinite number of circles, or other curves, all touching it and each other in the same point of contact. So that any curve may be touched by an infinite number of different circles at the same point; and some of these circles fall wholly within it, being more curved, or having a greater curvature than that curve; while others fall without it near the point of contact, or between the curve and tangent at that point, and so being less deflected from the tangent than the curve is, they have a less degree of curvature there; consequently there is one, of this infinite number of circles, which neither falls below it nor above it, but, being equally deflected from the tangent, coincides with it most intimately of all the circles; and the radius of this circle is called the radius of curvature of the curve; also the circle itself is called the circle of curvature, or the osculatory circle, of that curve, because it touches it so closely that no other circle can be drawn between it and the curve.

CURVE, in Geometry, is a line, the several parts of which proceed in different directions, and are successively posited towards different points in space.

A plane Curve, is that of which the several points in it lie in the same plane; and when this is not the case, the curve is said to be one of double curvature.

Curve *Lines* are distinguished into algebraical or geometrical, and transcendental or mechanical. *Algebraical* or *Geometrical* Curves, are those in which the relation of the abscisses to the ordinates can be expressed by a common algebraical expression. *Transcendental* or *Mechanical* Curves, are such as cannot be defined or expressed by an algebraical equation; or when they are expressed by an equation, one of its terms is a variable quantity, or a curve line.

Family of Curves, is an assemblage of several curves of different kinds, all defined by the same equation of an indeterminate degree; but differently, according to the diversity of their kind.

Curve of *Double Curvature*, is used to denote the curve-line, all the parts of which are not situated in the same plane. A curve which can only be traced upon a curve surface, and not upon a plane surface, is called a curve of a double curvature. These kinds of curves may be considered as generated by the track of a point which is moved upon a curve surface, the direction of its motion being continually deflected either towards the right, or towards the left hand; thus it happens that the line so described is curved, in two senses; for in effect, is partakes of the curvature of the curve surfaces, and of the continual and successive deflections of the describing point. Two curve surfaces which mutually penetrate each other, form also, in general, by their intersection, a curve of double curvature. Such, for example, is the curve which is formed by the mutual penetration of a right cylinder and a sphere, supposing that the axis of the cylinder does not pass through the centre of the sphere. We have said in general, for it may happen on account of particular circumstances, that the intersections of two curve surfaces is a plane curve. Thus, in the preceding example, if the axis of the cylinder passed through the centre of the sphere, the curve of intersection would be the common circle. Ingenious disquisitions on curves of double curvature, have been given by Euler and La Croix.

CURVILINEAR, any thing relating to curves, as curvilinear angle, figure, surface, &c. being such as are formed or bounded by curves.

CUSCUTA, *Dodder*, a genus of the digynia order, in the tetrandria class of plants, ranking in the natural method under the dubious order. There are four species, one of which is a native of Britain, *viz.* The Europæa, dodder, hell-weed, or devil's guts; a singular plant, almost destitute of leaves, creeping and fastening on whatever is next to it. It decays at the root, and afterwards is nourished by the plant to which it adheres. Hops, flax, and nettles are its common supporters.

CUSP, Cuspis, in Astronomy, properly denotes the point of a spear, but is used to express the points or horns of the moon, or other luminary.

Cusp, in Geometry, is used for the point, or corner, formed by two parts of a curve meeting and terminating there.

CUSTOM, a law, not written, which from long usage and consent becomes a matter of right. It is either general or particular; the first when allowed throughout England; particular when confined to a particular district.

Custom is also a very comprehensive term, denoting the manners, ceremonies, and fashions of a people, which having turned into a habit, and passed into use, obtains the force of laws; in which sense it implies such usages as, though voluntary at first, are yet, by practice, become necessary. Custom is hence defined, a law not written, but established by long usage, and the consent of our ancestors; in which sense it stands opposed to the written law. All customs ought to have a reasonable commencement, be certain, not ambiguous, have had uninterrupted continuance, and not be against the king's prerogative.

CUSTOM *of London:* it is a custom of London, that where a person is educated in one trade, he may set up another; that where a woman uses a trade without her husband, she is chargeable alone, as a *femme sole* merchant, and, if condemned, she be put in prison till she pays the debt; likewise the bail for her are liable if she abscut herself, and the husband, in these cases, shall not be charged. If a debtor be a fugitive, by the custom of London he may be arrested before the day, in order to find better security, &c. These are customs of London, different from those of other places.

CUSTOM *of Merchants:* if a merchant gives a character of a stranger to one who sells him goods, he may be obliged to satisfy the debt of the stranger for the goods sold, by the custom of merchants. And when two persons are found in arrears, upon an account grounded on the custom of merchants, either of them may be charged to pay the whole sum due, &c. Various other cases depend on what is understood as the usual custom of commercial men.

CUSTOMS, in Commerce, the duties or taxes payable upon the importation or exportation of merchandise. They appear to have been originally levied to reimburse the sovereign for the expense he incurred in protecting foreign trade, and were considered as taxes upon the profits of the merchants, being imposed equally upon all sorts of goods, necessaries as well as luxuries.

CUSTOS BREVIUM, the principal clerk in the Court of Common Pleas, who keeps all the writs made returnable in that court, and makes entries of writs of covenant, &c.

CUSTOS MESSIUM. Monsieur de la Lande introduced this asterism in honour of the celebrated astronomer Messier, and in allusion to his name it has been called the *Guardian of the Harvests.*—The boundaries and contents are: south by Cassiopeia, east by Cepheus, north by Tarandus, and west by Camelopardalis. Right ascension 35°, and 68° declination north. The stars, about ten in number, are mostly invisible to the naked eye.

CUSTOS ROTULORUM, an officer who has the care of the rolls and records of the sessions of peace, also of the commission of the peace.

CUT-WATER, in a ship, is the sharp part of the head under the beak or figure.

CUTICULA, in Anatomy, a thin membrane close upon the skin or cutis, of which it seems to be a part, and to which it firmly adheres by the corpus reticulare.

CUTIS, in Anatomy, the skin, that strong covering which envelopes the whole surface of animals, and which consists chiefly of two parts, a thin white elastic layer on the outside called the epidermis or cuticle; and a thick one composed of many fibres closely interwoven and disposed in different directions, called the cutis or true skin.

CUTLERY, in the general sense comprises all those articles denominated edge-tools, but it is more particularly confined to the manufacture of knives, forks, scissars, penknives, razors, swords, and surgical instruments.

CUTTER, a sloop-rigged vessel built sharp for sailing; generally used in smuggling, or in the navy to watch the coast, and to look after vessels engaged in contraband trade.

CYCAS, a genus of plants belonging to the first natural order palmæ. The fruit is a dry plum with a bivalve kernel. There are two species; 1. The circinalis or sago tree, which grows in the East Indies, particularly on the coast of Malabar. It rises to the height of forty feet, and the leaves are seven or eight feet long. The flowers grow in long bunches at the footstalks of the leaves, and are succeeded by oval fruit, about the size of large plums, of a red colour when ripe, and of a sweet taste. Each contains a nut enclosing a white kernel which tastes like the chestnut. The inhabitants of India saw the body of the tree into pieces, then beat them into a mortar and pour water upon it. When strained, a fine mealy substance comes off, which is made into bread. The same meal finely powdered is made into sago. 2. The cyas revoluta, or bread tree of the Hottentots, discovered by Thunberg, has a pith which abounds in the trunk, and is collected and tied up in skins, and buried some weeks till it is tender enough to be kneaded, and then it is made into loaves of frumenty.

CYCLE, a certain period or series of numbers, proceeding orderly from first to last, then returning again to the first, and so circulating perpetually. Cycles have chiefly arisen from the incommensurability of the revolutions of the earth and celestial bodies to one another. The apparent revolution of the sun about the earth, has been arbitrarily divided into 24 hours, which is the basis or foundation of all our mensuration of time, whether days, years, &c. But neither the annual motion of the sun, nor that of the other heavenly bodies, can be measured exactly, and without any remainder, by hours, or their multiples. That of the sun, for example, is 365 days, 5 hours, 49 minutes, nearly; that of the moon, 29 days, 12 hours, 44 minutes, nearly. Hence, in order to express these fractions in whole numbers, and yet in numbers which only express days and years, cycles have been invented; which, comprehending several revolutions of the same body, replace it, after a certain number of years, in the same points of the heaven whence it first departed; or, which is the same thing, in the same place of the civil calendar.

The most remarkable of these are the following:—*The Cycle of the Sun*, or *Solar Cycle*, is a revolution of 28 years, in which time the days of the months return again to the same days of the week; the sun's place to the same signs and degrees of the ecliptic on the same month and days, so as not to differ one degree in 100 years; and the leap-years begin the same course over again, with respect to the days of the week on which the days of the month fall. *The Cycle of the Moon*, commonly called the *Golden Number*, is a revolution of 19 years; in which time the conjunctions, oppositions, and other aspects of the moon, are within an hour and a half of being the same as they were on the same days of the months 19 years before. The Indiction is a revolution of 15 years, used only by the Romans, for indicating the times of certain payments, made by the subjects to the republic. It was established by Constantine, A. D. 312.

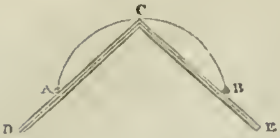
The year of our Saviour's birth, according to the vulgar æra, was the ninth year of the solar cycle, the first year of the lunar cycle; and the 312th year after his birth, was the first year after the Roman Indiction. Hence, *to find the year of the Solar Cycle*, add 9 to any given year of Christ, and divide the sum by 28, the quotient is the number of cycles elapsed since his birth, and the remainder is the cycle for the given year: if nothing remains, the cycle is 28.

To find the Lunar Cycle.—Add one to the given year of Christ, and divide the sum by 19; the quotient is the number of cycles elapsed in the interval, and the remainder is the cycle for the given year: if nothing remains, the cycle is 19. Lastly, subtract 312 from the given year of Christ, and divide the remainder by 15, and what remains, after this division, is the Indiction for the given year: if nothing remains, the Indiction is 15.

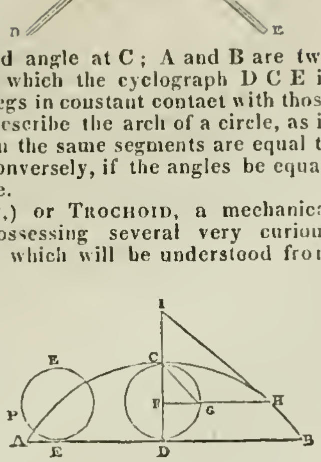
The Cycle of Easter, also called the *Dionysian Period*, is a revolution of 532 years; found by multiplying the solar cycle 28, by the lunar cycle 19. If the new moons did not anticipate upon this cycle, Easter-day would always be the Sunday next after the full moon which follows the twenty-first of March; but, on account of the above anticipation, to which no proper regard was had before the late alteration of the style, the ecclesiastic Easter has several times been a week different from the true Easter, within this last century; which inconvenience is now remedied by making the table, which used to find Easter for ever, in the Common Prayer Book, of no longer use than the lunar difference from the new style will admit of. The earliest Easter possible, is the 22d of March; the latest, the 25th of April. Within these limits are thirty-five days, and the number belonging to each of them is called the Number of Direction; because, thereby, the time of Easter is found for any given year.

CYCLOGRAPH, an instrument, as its name imports, used for describing the arcs of circles, in some cases where compasses cannot be employed.

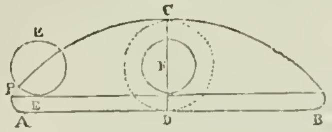
The most simple cyclograph, next to the compasses, is that commonly used by artificers in describing arches for the tops of doors, windows, &c. D C E represent two rods, forming any determined angle at C; A and B are two fixed pins or nails, between which the cyclograph D C E is made to move, keeping both legs in constant contact with those points; so will the angle C describe the arch of a circle, as is obvious, because all angles in the same segments are equal to each other; and, therefore, conversely, if the angles be equal, the curve is the arc of a circle.



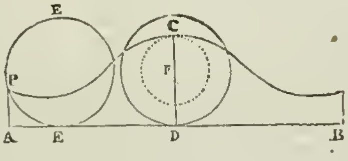
CYCLOID, (in Geometry,) or TROCHOID, a mechanical or transcendental curve, possessing several very curious properties, the generation of which will be understood from the following figure. Conceive the circle E P E to rotate along the right line A B, in the same plane with the circle, until a fixed point P in the circumference, which at first touched the right line at A, touches it again at B, after an entire revolution; then the curve A C B, traced upon the plane by the point P, is called a cycloid.



The line A B is called the *base*, and D C the *axis* of the cycloid; and the circle E P E the *generating circle*.



If the point P be without the circumference of the generating circle, then the curve described by that point is properly called a *trochoid*, but commonly also a *curtate cycloid*.



And if the point P be within the circumference of the generating circle, then the curve is called the *prolate cycloid*.

If the generating circle, instead of revolving along a right line, as in the above figures, is made to revolve along either the concave or convex circumference of another circle, then the curve so generated is called an EPICYCLOID; the principal properties of which will be found under that article. The cycloid is a modern curve, the invention of which has been attributed to Bovillus, who wrote about the year 1501.

We cannot, in this place, enter into an investigation of the several curious properties which belong exclusively to the cycloid, as this would occupy much more space than can with propriety be allotted to this article; we must, therefore, content ourselves with enumerating the principal of them.

Properties of the Cycloid.—Draw any right ordinate F G H, fig. 1. above, join C G, and from H draw H I parallel to C G, meeting the axis D C produced in I. Then, 1. I H is a tangent to the cycloid at the point H. 2. The circular arc C G is equal to the right line H G. 3. The semi-circumference C G D = semi-base D B. 4. The cycloidal arc C H = double the chord C G. 5. The semi-cycloidal arc C B = double the diameter C D. 6. The area of the cycloid A C B A = triple the area of the circle C G D. 7. The three spaces A C D, the circle C G D, and C B D, are equal to each other. 8. The upper segment of a cycloid cut off by a line parallel to the base, at $\frac{1}{4}$ of the axis from the vertex, is equal to the regular hexagon inscribed in the generating circle. 9. The solid generated by the revolution of the cycloid about its base A B, is, to its circumscribing cylinder, as 5 to 8. 10. The solid generated about the tangent parallel to the base, is, to its circumscribing cylinder, as 7 to 8. 11. And the solid generated about the tangent parallel to the axis, is, to its circumscribing cylinder, as 6 to 8.

CYCLOPTERUS, *the Sucker*, a genus of fishes belonging to the order of amphibia nantes, of which there are three species, 1. The lumpus or lump fish, is in length nineteen inches, and weighs seven pounds. These fish abound in the Greenland seas, and on the coast of Scotland. 2. The liparis or sea snail, of a soft unctuous texture, and soon melts away, is in length five inches, and the colour a pale brown. 3. Cyclopterus minor, or the lesser sucking fish, is found on the coast of Britain. It is about four inches, and fastens very tenaciously to stones and rocks.

CYDER. We have already treated of CIDER, and as the two modes of spelling this word frequently occur, we have taken leave, under the present orthography, to insert some directions which may prove useful, in those families and countries where cyder is a common drink. Let your fruit be as near the same ripeness as possible, otherwise the juice will not agree in fermenting. When they are properly sweated, grind and press them; and as soon as you have filled a cask, if a hogshead, which is one hundred and ten gallons, ferment it as follows; and if less, proportion the ingredients to your quantity.

A Ferment for Cyder.—To one hogshead of cyder, take three pints of solid yeast, the mildest you can get; if rough, wash it in warm water, and let it stand till it is cold. Pour the water from it, and put it in a pail or can; put to it as much jalap as will lay on a sixpence, beat them well together with a whisk, then apply some of the cyder to it by degrees till your can is full. Put it all to the cyder, and stir it well together. When the ferment comes on you must clean the bung-holes every morning with your finger, and keep filling the vessel up. The ferment for the first five or six days will be black and stiff; let it stand till it ferments white and kind, which it will do in fourteen or fifteen days; at that time stop the ferment, otherwise it will impair its strength.

To stop the Ferment.—In stopping this ferment, which is a very strong one, you must first rack it into a clean cask, and when pretty near full, put to it three pounds of coarse, red, scowering sand, and stir it well together with a strong stick, and fill it within a gallon of being full; let it stand five or six hours, then pour on it as softly as you can a gallon of English spirit, and bung it up close; but leave out the vent-peg a day or two. At that time just put it in the hole, and close it by degrees till you have got it close. Let it lay in that state at least a year; and if very strong cyder, such as stire, the longer you keep it the better it will be in the body; and when you pierce it, if not bright, force it in the following manner.

A Forcing for Cyder.—Take a gallon of perry or stale beer, put to it one ounce of isinglass, beat well, and cut or pulled to small pieces; put to it the perry or beer, and let it steep three or four days. Keep whisking it together, or else the glass will stick to the bottom, and have no effect on the liquor. When it comes to a stiff jelly, beat it well in your can with a whisk, and mix some of the cyder with it till you have made the gallon four; then put two pounds of brick rubbings to it, and stir it together with two gallons of cyder more added to it, and apply it to the hogshead; stir it well with your paddle, and shive it up close. The next day give it vent, and you will find it fine and bright. If you force perry, cut your isinglass with cyder or stale beer, for no liquor will force its own body.

To cure Acid Cyder.—It is always to be observed, that even weak *alkalies* cure the strongest acid, such, for instance, as calcined chalk, calcined oyster or scallop-shells, calcined egg-shells, alabaster, &c. But if a hogshead can soon be drank, use a stronger *alkali*, such as salt of tartar, or salt of wormwood; but in using them you must always preserve their colour with *lac*, or else the *alkali* will turn the liquor black, and keep it foul.

To one hogshead, take two gallons of *lac*[*], and put to it one ounce and a half of isinglass, beat well, and pulled small; boil them together for five or six minutes; strain it, and when a stiff jelly, break it with a whisk, and mix about a gallon of the cyder wth it; then put three pounds of calcined chalk, and two pounds of calcined oyster-shells to it, whisk it well together with four gallons more of the cyder, and apply it to the hogshead. Stir it well, and it will immediately discharge the acid part out at the bung. Let it stand one hour, then bung it close or five or six days; rack it from the bottom into a clean hogshead, and apply one quart of forcing to it. If you use a strong *alkali*, put to the *lac* four ounces of salt of tartar, or salt of wormwood; but the former is best, as it hath not the bitter taste in it which the wormwood has.

---

[*] *Lac* is milk, but the cream must be skimmed off it for use.

To cure Oily Cyder.—The reason that cyder is sometimes oily, is owing to the fruit not being sorted alike; for the juice of fruit that is not ripe will seldom mix with ripe juice in fermentation. The acid part of one will predominate over the other, and throw the oily particles from it, which separation gives the liquor a disagreeable, foul taste; to remedy which, you must treat it in the following manner, which will cause the oily parts to swim at top, and then you may rack the liquor from its bottom and oil.

To a hogshead, take an ounce of salt of tartar, and two ounces of half sweet spirit of nitre, mix them in a gallon of *lac*, and whisk them well together; apply it to the hogshead, bung it up, and let it stand ten or fifteen days; then put a cock within two inches of the bottom of the hogshead, and rack it.

Observe when it runs low to look to the cock, lest any of the oily part should come, which will be all on the top, and will not run out till after the good liquor is drawn off.

Put to the clean a quart of forcing, to raise it, and bung it close.—When you take out the oil and bottom, your cask must be well fired, otherwise it will spoil all the liquor that shall be afterwards put into it.

For Ropy Cyder.—The following remedy for ropy cyder must be proportioned with judgment to the degree of the disorder in the liquor. If the rope be stiff and stringy, you must use a larger quantity of the ingredients.

If a hogshead be quite stiff and stringy, work it at least an hour with your paddle, then put to it six pounds of common alum, ground to a fine powder; work it for half an hour after, and bung it up close. This in a week will cut the rope, and bring it to a fine, thin, fluid state. Then rack it into a clean hogshead, and put to it one quart of forcing; stir them well in the hogshead, and bung it close up. If but a thin rope, use a less quantity of the alum, and work it the same way.

Cyders bad-flavoured.—Some cyders in keeping are apt to get reasty, through the ill quality of the fruit; and sometimes through the badness of the cask will get musty, or fusty.

To remedy these evils, you must throw it in ferment, if its body is strong, with yeast and jalap, and let it ferment three or four days; which will throw off the greatest part of the taste; then stop the ferment. If a hogshead, put to it one pound of sweet spirit of nitre, and bung it up close. This will cure the bad flavour, if any be left, and likewise keep it from growing flat.

To colour Cyder.—In many places, particularly where the soil is light, and the orchard lies rising, the juice of the fruit is nearly white, and though the cyder may be strong, it does not appear to be so by reason of its colour, which always prejudices the buyer against it.

Many people spoil a great deal of good cyder by boiling and mixing molasses with it, to give it a colour which not only gives it a bad red colour, but makes it muddy as well as bad-tasted. Others again will boil a large quantity of brown sugar, and mix with it, which gives it a colour indeed, though a light one; when two pounds of good sugar, properly used, is sufficient to colour ten hogsheads, as follows:

Take two pounds of powder sugar, the whiter the sugar the farther it will go, and the better the colour will be. Put it in an iron pot or ladle; set it over the fire, and let it burn till it is black and bitter; then put two quarts of boiling hot water to it; keep stirring it about, and boil it a quarter of an hour after you have put the water to it. Take it off the fire, and let it stand till it is cold, then bottle it for use.

Half a pint of this will colour a hogshead. Put to each half-pint, when you use it, a quarter of an ounce of alum ground, to set the colour.—*See* Cider.

CYDONIA, *the Quince*, so called from Cydon in Crete, which abounds with this fruit. The species are, 1. The oblonga, with an oblong fruit, lengthened at the bases. 2. The maliforma with oval leaves, woolly on the upper side. The most valuable is that called the Portugal quince, the pulp of which turns to a fine purple, and makes a good marmalade.

CYGNUS, is fabled by the Greeks to be the *Swan*, under the form of which Jupiter deceived Leda or Nemesis, the wife of Tyndarus, king of Laconia. Leda was the mother of Pollux and Helena, the most beautiful woman of her age, and also of Castor and Clytemnestra. The two former were deemed the offspring of Jupiter, and the others claimed Tyndarus as their father. According to another fable, Orpheus, the celebrated musician of antiquity, having been killed by the cruel priestess of Bacchus, the gods metamorphosed him into a *Swan*, and placed him among the stars by the side of his lyre.

Boundaries and Contents.—Cygnus is situated in the Milky Way, and is bounded on the north by Draco, east by Lacerta and Pegasus, south by Vulpecula et Anser, and west by Lyra. There are eighty-one stars in this constellation, *viz.* one of the 1st or 2d magnitude, six of the 3d, twelve of the 4th, &c. The most brilliant star in Cygnus is called *Deneb*, whose right ascension is 308° 49′ 19″, and its descension 44° 38′ 32″ north. The greater part of this constellation never sets in lat. 51° north; and *Deneb* culminates at London, for the first day of every month, as in the following table: Meridian Altitude, 83° 7′ 32″.

Month.	Culm.	Month.	Culm.	Month.	Culm.
	ho. mi.		ho. mi.		ho. mi.
Jan.	2 0 A.	May	6 0 M.	Sept.	9 50 A.
Feb.	11 40 M.	June	3 55 M.	Oct.	8 10 A.
March	9 45 M.	July	1 55 M.	Nov.	6 15 A.
April	7 45 M.	Aug.	11 50 A.	Dec.	4 15 A.

CYLINDER, is a solid having two equal circular ends parallel to each other, and every plane section parallel to the ends is also a circle, and equal to them. Cylinders are either *right* or *oblique*.

Fig. 1.

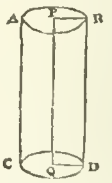
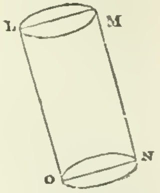


Fig. 2.



A *Right* Cylinder, is that whose side is perpendicular to the plane of its base, as the figure ABCD fig. 1.

An *Oblique* Cylinder, is that whose side is not perpendicular, but oblique to the plane of its base, as L M N O, fig. 2. A right cylinder may be conceived to be generated by the revolution of a rectangle, as P B D Q, about one of its sides P Q, which remains fixed, and which is called the axis of the cylinder. Or we may otherwise conceive it to be generated by carrying a right line parallel to itself, about the circumferences of two equal and parallel circles; which answers as well for the oblique, as for the right cylinder.

To find the Surface and Solidity of a Cylinder, whether right or oblique.—1. Multiply the circumference of its base by its length, and the product will be the area. 2. Multiply the area of its base by its perpendicular height, and the product will be the solidity.

CYLINDRIC, or Cylindrical, any thing relating to the cylinder. Cylindric *Ring*, is a solid which may be conceived, by supposing a cylinder to be bent round into a circular form, so as to return upon itself.

To find the Surface and Solidity of a Circular Ring.—1. Multiply the circumference of a perpendicular section of the ring, by half the sum of the inward and outward diameters, and that product again by 3·1416, and the last product will be the surface of the ring. 2. Multiply the area of a perpendicular section by the same quantities, and the last product will be the solidity.

CYMATIUM, in Architecture, a member or moulding of the cornice, the profile of which is concave at the top and convex at the bottom.

CYMBAL, a musical instrument of antiquity. It was round, and made of brass like our kettle-drums, but smaller, and applied to a different use.

CYNARA, *the Artichoke*, a genus of the polygamia æqualis order, and of the syngenesia class of plants. There are four species, but only two are cultivated for use. The garden artichoke, which is either the conical green-headed French artichoke, or the globular-headed red Dutch artichoke; and the cardoon, which is larger than the preceding. The former is propagated by slips or suckers, and the latter by seed.

CYNICS, a sect of ancient philosophers, who valued themselves upon their contempt of riches and state, arts and sciences, and every thing, in short, except virtue or morality.

CYNIPS, a genus of insects of the order of hymenoptera, of a bright brown colour, and produced in the hard galls under the oak leaves, being deposited there by the gall-fly. The oak-bud cynips is of a shining green colour, and there are nineteen species of this insect.

CYPERUS, a genus of the monogynia order, in the triandria class of plants, ranking in the natural method under the 3d order, calamariæ, of which there are fifty-three species, the principal of which are the round, the long sweet cyperus, and the papyrus. The long cyperus is used by perfumers and glovers. The papyrus is celebrated for its early use as paper.

CYPHER, or CIPHER. To write in cypher denotes the art of communicating by writing in such a manner as shall be legible only to those who are acquainted with the rules by which the characters made use of are formed or disposed. It is principally used in diplomatic correspondence, or on other national affairs, such as those relating to the operations of war. As the nature of alphabetic writing, and the structure of languages, necessarily imply certain indispensable habitudes of the letters and words, it often happens that the laws or conditions made use of for the sake of secrecy can be detected by skilful persons, and the secret by that means discovered. The art of discovering the sense of writings of the description here mentioned, is called decyphering.

CYPRÆA, or COWRIE, a genus of insects of the order of vermes testaceæ. It is of the snail kind; and there are forty-four species, distinguished by the form of their shells, which are used as money in Bengal and on the coast of Guinea.

CYPRESS. *See* CUPRESSUS.

CYPRINUS, a genus of fishes of the order of abdominales, of which there are thirty-one species, as, 1. The carp, found in the rivers and lakes of Polish Prussia, &c. Carp is a long-lived fish, and instances are related of some that have attained the age of 100 years. The carp is very cunning, and on that account is called the river fox. It is very shy in taking a bait, but in spawning time it is easily caught. In Prussia, carp are often kept some time out of water, and grow fat in their new element. They are suspended in a net in a cellar, and plunged in water every four or six hours. 2. The barbel, a coarse fish, whose roe is so noxious as to produce vomiting, purging, and a swelling in those who unwarily eat of it. The barbel is about three feet long, and the dorsal fin is armed with a strong spine, with which it inflicts a dangerous wound. 3. The tench, reckoned a delicious food in this country, weighs generally 4 or 5lbs. and is thick and short. The colour of the back is dusky, but the head, sides, and belly are greenish with a mixture of gold. 4. The gudgeon, found in gentle streams, seldom weighs more than half a pound. 5. The bream, which inhabits lakes or the deep parts of still rivers, is an insipid fish. 6. The roach is a common river fish, never exceeding five pounds. 7. The dace, also common, and a great breeder, is often seen in the summer frolicking on the water. The general weight is less than 2lbs. 8. The cephalus or chub, is a coarse bony fish, that frequents the deep holes of rivers. 9. The bleak, is common in many rivers. At some seasons they are so much agitated as to be called mad-bleak by the fishermen. It is supposed that this is occasioned by a hair-worm, which attacks them, and of which they die. Artificial pearls are made of the scales of this fish, and also of those of the dace. The usual length of the bleak is two inches. 10. The gold fish, a small beautiful species, domesticated in China, and much valued as an ornament for courts and gardens. The gold and silver fish were introduced into England generally in 1723.

D.

D, the fourth Letter of the Alphabet, and as a numeral denoting 500, with a dash over it, $\overline{D}$ 5000. In abbreviation it has various significations, as D. D. doctor in divinity; M. D. doctor in medicine. In Music, D marks in thorough bass what the Italians call descanto, denoting that the treble ought to play alone, as T does the tenor, and B the bass. D C means the abbreviation of de capo, or from the head.

DÆMON, a name given to certain spirits, or genii, which, it is said, appeared to men.

DAIRY, in rural affairs, a place appointed for the management of milk, and the making of butter, cheese, &c. Dairy-houses are to be kept perfectly clean; and lattices are to be preferred to windows; and if their situation can be fixed beside a spring or current of water, it is to be preferred. The proper receptacles for milk are earthen pans, or wooden vats, and lead should not be used on any account, as it is highly poisonous, unless the greatest care be used to scald it daily.

DAMAGE, in Law, is generally understood of a hurt or hinderance attending a person's estate; but in Common Law, it is a part of what the jury are to inquire into, relative to the plaintiff or defendant.

DAMAGE *faisant*, is where the beasts of another come upon a man's land and spoil his corn or grass, in which case the owner may impound them till satisfaction be obtained.

DAMASK, a sort of silken stuff, both in warp and woof; or with the warp silk, and the woof thread; or all thread, or all wool. And *Damaskeening* is the art of beautifying iron, or steel, by inlaying it with gold or silver wire, as in sword blades, guards, and gripes, locks of pistols, &c. Were the artists of Britain to turn their attention to this subject, they might soon rival all other countries in the world in damaskeening steel.

DAMPS, noxious exhalations issuing from the earth, and which almost instantly prove fatal to those who breathe them. We allude here chiefly to *coal mine damps*, called *choke* and *fire* damps; the former is *carbonic acid gas*, generally prevalent in wastes, or neglected works; the latter is *hydrogen gas*, or inflammable *air*. *See Safety Lamp.*

DARK RAYS, in Philosophy, are certain emanations from the sun, that have been recently discovered, which are not perceptible to our eyes, and are only manifested by their effects on the thermometer. Thus when the rays of the sun are refracted by a glass prism, and form the coloured spectrum upon any surface, a thermometer placed beyond the spectrum is elevated by the heat of certain rays, or emanations, which are by no means visible; and which have thence been denominated calorific rays.

DATA, in Mathematics, denote certain quantities which are given or known, and by means of which other quantities, which are unknown, are to be determined. Euclid, in his book of "Data," uses this term to denote such spaces, lines, angles, &c. as are given, or to which others may be found equal.

DATE, in Law, the description of the day, month, year of our Lord, and year of the king in which a writing is made. In writings of importance, the date should be in words at length. An *ante*-date is that prior to the real time when the instrument was signed. A *post*-date is that which is posterior to the real time.

DAY, in Astronomy, is that portion of time which elapses between two successive transits of the sun over the same meridian; and the time is reckoned from noon to noon, and consists of twenty-four hours. This is called a *natural* day, being of the same length in all latitudes. The *artificial* day is the time elapsed between the sun's rising and setting, and is variable according to the different latitudes of places.

A *mean Solar Day* is measured by equal motion, as by a clock or timepiece, and consists of twenty-four hours. There are, in the course of a year, as many mean solar days as there are true solar days, the clock being as much faster than the sun-dial on some days of the year, as the sun-dial is faster than the clock on others. Thus the clock is faster than the sun-dial from the twenty-fourth of December to the fifteenth of April, and from the sixteenth of June to the thirty-first of August; but from the fifteenth of April to the sixteenth of June, and from the thirty-first of August to the twenty-fourth of December, the sun-dial is faster than the clock. When the clock is faster than the sun-dial, the true solar day exceeds twenty-four hours; and when the sun-dial is faster than the clock, the true solar day is less than twenty-four hours; but when the clock and the sun-dial agree, *viz.* about the fifteenth of April, sixteenth of June, thirty-first of August, and twenty-fourth of December, the true solar day is exactly twenty-four hours.

Days of the Week.—These are Sunday, Monday, Tuesday, Wednesday, Thursday, Friday, and Saturday.

The Nautical Day commences, either by observation or account, when the sun is on the meridian, which is generally supposed to be our 12 o'clock at noon on shore. At that moment, the officer of the watch, or more commonly the master of the ship, orders the marine sentinel to turn a half-hour sand glass, which he has always in charge, which has been previously run out, and *strike eight bells forward;* which is accordingly done, and the dinner is piped. No sooner is this glass run out, than the sentinel calls, " Strike the bell *one*, forward ;" and again turns it, when the grog is immediately piped. When it runs out a second time, he again calls, " Strike the bell *two*, forward ;" which is no sooner done, than the boatswain's mate calls the afternoon watch. Thus he proceeds until he comes to the *eighth* bell, which is no sooner struck, than the watch expires, and the grog is again piped. Previous to this, however, in order to relieve the quartermaster, the helmsman, the look-out at the mast head, and the sentinel at the glass, an individual of each of these classes of the watch below, goes, when the seventh bell is struck, to the purser's steward, gets his quartern of grog unmixed, takes his supper, and is ready, as soon as the 8th strikes, to relieve his man with the rest of the watch. All hands now take supper; and when one bell again strikes, the first *dog watch* is called. This is only a watch of two hours; and accordingly when the 4th bell has struck, the second *dog watch* is called, which lasts other two hours, and brings the supposed time pretty accurately to our eight o'clock at night. By this time, however, the hammocks having been piped down, the watch relieved generally retires to rest. The watch on deck, therefore, execute all the necessary duties of the ship until their 8th bell is struck; when the *middle watch* is called; and these again are relieved in the same time by the *morning watch*, who do the ship's duty during other eight bells, which brings the time to our eight o'clock in the morning, when breakfast is always piped. As usual at *one bell*, the forenoon watch is called, who do the duties of the deck while the watch below are fumigating or scrubbing the lower deck, or probably mending their clothes; and thus they continue until the *observation of the sun at noon* is again taken, if the weather is favourable, and any necessary correction made on the time lost or gained. When the *eighth* bell is once more struck, the *day at sea* is completed, the glass is turned to commence a new one, the dinner is piped, and the watch called as before.

Days *of Grace*, in Commerce, are those allowed for the payment of a bill of exchange after the sum becomes due. In England they are three.

DAY'S WORK, the reckoning or account of a ship's course or distance run during 24 hours, or from noon to noon, according to the rules of TRIGONOMETRY.

DAVIT, a strong beam of timber used as a crane, whereby to hoist the flukes of the anchor to the top of the bow, without injuring the planks of the ship's side as it ascends; an operation which, by seamen, is called fishing the anchor; the lower end of the davit rests on the fore chains, the upper end being properly secured by a tackle from the mast head; upon the other end is hung a large block, through which a strong rope is reeved, called the fish-pendant, to whose outer end is fitted a large hook, and to its inner end a tackle; the former is called the fish-hook, the latter the fish-tackle. The anchor being first catted, the fish-hook is fastened on its flukes, and is, by means of the fish-pendant and tackle, drawn up sufficiently high upon the bow to be made fall by the shank-painter. Thus the davit, according to the sea phrase, is employed to fish the anchor. There is also a davit of a smaller kind, occasionally fixed in the longboat, and, with the assistance of a small windlass, used to weigh the anchor by the buoy-rope, &c.

DEACON, one of the three holy orders of the church, being that next below the priesthood.

DEAD EYE, or DEAD MAN'S EYE, a sort of round flattish wooden block encircled with a rope, or with an iron band, and pierced with three holes through the flat part, in order to receive a rope called the laniard, which corresponding with three holes in another dead eye, creates a purchase employed for various uses, but chiefly to extend the shrouds and stays, otherwise called the standing rigging. In order to form this purchase, one of the dead eyes is fastened in the upper link of each chain on the ship's side, which is made round to receive and encompass the hollowed outer edge of the dead eye. After this the laniard is passed ultimately through the holes in the upper and lower dead eyes, till it becomes sixfold, and is then drawn tight by the application of mechanical powers. In merchant ships they are generally fitted with iron plates, in the room of chains. The dead eyes used for the stays have only one hole, which, however, is large enough to receive ten or twelve turns of the laniard; these are generally termed *Hearts*. The crowfeet *Dead Eyes*, are long cylindrical blocks, with a number of small holes in them, to receive the legs, or lines, of which the crow foot is composed.

DEAD LIGHTS, strong wooden ports made exactly to fit the cabin windows, in which they are fixed on the approach of a storm, the glass frames being taking out, which would otherwise be shattered by the violence of the waves, and let great quantities of the water pour into the ship.

DEAD RECKONING, the judgment or estimation which is made of the place where a ship is situated, without any observation of the heavenly bodies; it is discovered by keeping an account of the distance she has run by the log, and of her course steered by the compass, and by rectifying these data by the usual allowances for drift, leeway, &c. according to the ship's known trim; this reckoning is, however, always to be corrected as often as any good observation of the sun can be obtained.

DEAD RISING, or RISING LINE of the floor, those parts of a ship's floor or bottom throughout her whole length, where the floor timber is terminated on the lower futtock.

DEAD ROPES, are those which do not run in any block.

DEAD WATER, the eddy of water which appears like little whirlpools closing in with the ship's stern as she sails through it.

DEAD WOOD, in Naval Architecture, certain blocks of timber laid upon the keel, particularly at the extremities afore and abaft, where these pieces are placed upon each other to a considerable height, because the ship is there so narrow as not to admit of the two half timbers, which are therefore scored into this dead wood, when the angle of the floor timbers gradually diminishes as approaching the stem and stern post. In the fore part of the ship, the dead wood generally extends from the stemson, upon which it is scarfed, to the loof frame; and in the after end from the sternpost, where it is confined by the knee to the after balance-frame. It is connected to the keel by strong spike nails. The dead wood afore and abaft is equal in depth to two-thirds of the depth of the keel, and as broad as can be procured, so as not to exceed the breadth of the keel.

DEAD WORKS, all that part of the ship which is above water when she is laden. The same as UPPER WORK.

DEAFNESS, the want of the sense of hearing, arising either from an obstruction or a compression of the auditory nerves, or from some collection of matter in the cavities of the inner ear, or from the auditory passage being stopped by some hardened excrement; or, lastly, from some excrescence, a swelling of the glands, or some foreign body introduced within the ears. Persons born deaf are also dumb.

DEAL, a plank of fir, made by sawing the trunk of the tree longitudinally. Deals are hardened by throwing them into salt water as soon as they are sawed, and keeping them therein some days, and then drying them in the sun.

DEAN, an ecclesiastical dignitary next to the bishop, and head of the chapter in a cathedral church. There are deans also who have no chapters, as the dean of Battle, the dean of Bocking, &c. Rural deans have no judicial authority, but a right of visiting churches within their district, and reporting the condition of the same to the ordinary.

Dean and *Chapter*, are the bishop's council to assist him in the affairs of religion, and to assent to every grant which the bishop shall make to bind his successors. As a deanery is a spiritual dignity, hence a man cannot be a dean and prebendary of the same church.

DEATH, physically, the extinction of animal life. In Law, there is a natural death and a civil death; the former where a person actually dies, the latter where he is adjudged to be so in law. Thus if a person, for whose life an estate is granted, is absent seven years, and there is no proof of his being living, he shall be accounted as dead.

DEATH-WATCH, a small insect which makes a ticking noise like the beating of a watch. There are two species, one of a dark brown colour, spotted, having pellucid wings under the vagina, a cap on the head, and two antennæ proceeding from beneath the eyes. The noise which it makes is a signal between the male and female. The second kind is a small grayish insect, much like a louse when viewed with the naked, unassisted eye.

DEBENTURE, a Custom-house certificate delivered to the exporter of goods, by virtue of which he is entitled to a bounty or drawback.

DEBT, National, the engagement entered into by a government, to repay at a future period money advanced by individuals for the public service, or to pay the lenders an equivalent annuity. National debts have arisen from the necessity of obtaining larger sums of money than could be raised at the time they were wanted by direct contributions; and often, when it would have been absolutely impossible to raise the requisite sum if a heavy tax had been imposed, and strictly levied, it has been deemed more prudent to avoid the evils attendant on such a measure by the less obnoxious expedient of a loan. In most countries, the subordinate governors, to whom is generally consigned the task of providing for the public expenses, being desirous of popularity, have shewn a great predilection for this mode of obtaining money, as it enables them to support a profuse expenditure, without appearing to oppress the people in so great a degree as they otherwise must: the system of getting into debt, or the funding system, as it is generally called, from particular funds being usually appropriated for payment of interest on the debts contracted, has therefore been adopted by most of the states of Europe, by many of the colonies, and by the American republics.—Watkins' *Cyclopædia.*

DECACHORDON, a musical instrument like the harp with ten strings, called by the Hebrews nasur.

DECAGON, a plane geometrical figure, of ten sides and ten angles. When all the sides and angles are equal, it is a regular decagon, and may be inscribed in a circle; otherwise not. If the radius of a circle, or the side of the inscribed hexagon, be divided in extreme and mean proportion, the greater segment will be the side of a decagon inscribed in the same circle. And, therefore, as the side of the decagon is to the radius, so is the radius to the sum of the two.

DECEMBER, The Botanical Kalendar for, instructs us that the gardener's operations are chiefly of the laborious kind; but long nights and short days give him ample leisure for study, unless he be of the slovenly tribe of gardeners, whose minds resemble their gardens, and are known rather by the excellence and growth of the weeds, than by order, regularity, progress, and scientific reputation.

In the Kitchen Garden, this month sow peas, beans, and radishes; but consider the result uncertain. Protect beans, transplant cabbages; earth up peas and beans; cover their stems with ashes, sawdust, or old tan. Tie up endive; weed and hoe; tie up esculents, as borecoles; destroy slugs, snails, mice; and fill the ice-house.

In the hardy Fruit Department, we plant the apple, pear, gooseberry, currant, &c. in mild weather; and all trees not pruned in November are now to be pruned. In the routine of culture, trench, dig, and ridge up in dry weather. Exhausted soils must now be recruited; larvæ of moths must be destroyed; and the temperature of the fruit cellars must be kept from 30° to 40°.

In the culinary Hot-house Department, sow small sallads, give abundance of air in dry weather, but protect in frosts. Begin to force asparagus, prepare cucumber beds; keep a steady heat in the pinery; and let the forcing houses be regularly attended to.

Little is done in the flower department this month, except in a liberal use of ashes, tan, &c. to bulbs, hydrangeas, &c. Attend to alpines, florists' flowers, annuals, &c. In the greenhouse the lowest temperature must be 42°, the highest 46°. The dry stove may average from 45° to 50°. But the back stove must average from 55° to 58°.

In the Pleasure Ground and Shrubbery, plant, prune, protect according to the weather; repair walks, roll them; sweep and clean lawns, lay down turf; and fell all trees that are to be removed as useless, or for their timber and bark.

DECEMVIRI, ten magistrates chosen yearly at Rome to govern the commonwealth instead of consuls.

DECIDUOUS, in Botany, a term expressive of the second stage of duration in plants, but susceptible of different senses, according to the particular part of the plant to which it is applied. A leaf is said to be deciduous which drops in autumn; petals are deciduous which fall off with the stamina and pistillum; and this epithet is applied to such flower-cups as fall after the expansion, and before the dropping of the flower.

Most plants in cold and temperate climates shed their leaves yearly. This happens in autumn, and is generally announced by the flowering of the common meadow saffron. The term is only applied to trees and shrubs; for herbs perish down to the root every year, losing stem, leaves, and all. All plants do not drop their leaves at the same time. Among large trees, the ash and walnut, although latest in unfolding, are soonest divested of them: the latter seldom carries its leaves above five months. On the oak and horn-beam the leaves die and wither as soon as the cold commences; but remain attached to the branches till they are pushed off by the new ones, which unfold themselves the following spring. These trees are doubtless a kind of evergreens; the leaves are probably destroyed only by cold; and, perhaps, would continue longer upon the plant, but for the force of the spring-sap, joined to the moisture.

With respect to the deciduous trees, the falling off of the leaves seems principally to depend on the temperature of the atmosphere, which likewise serves to hasten or retard the appearance in question. An ardent sun contributes to hasten the dropping of the leaves. Hence, in hot and dry summers, the leaves of the lime-tree and horse-chesnut turn yellow about the 1st of September; whilst, in other years, the yellowness does not appear till the beginning of October. Nothing, however, contributes more to hasten the fall of the leaves than immoderate cold or moist weather in autumn; moderate droughts, on the other hand, serve to retard it. It deserves to be remarked, that an evergreen tree grafted upon a deciduous, determines the latter to retain its leaves. This observation is confirmed by repeated experiments, particularly by grafting the laurel, or cherry-bay, an evergreen, on the common cherry; and the ilex, or evergreen oak, on the oak.—Watkins' *Cyclopædia*

DECIES TANTUM, in Law, a writ that lies against a juror, who has been bribed to give his verdict.

DECIMAL, Arithmetic, (*Decimal Tenths,*) in a general sense, denotes the common arithmetic, in which we count by periods of tens; and is otherwise, and more properly, called *Denary Arithmetic*, to distinguish it from the *Binary*, *Duodenary*, and other scales of arithmetic.

Decimal *Fraction*, is a fraction having always some power of 10 for its denominator, which consists of either 10, 100, 1000, &c. denoting the number of equal parts into which the integer or whole is supposed to be divided, as $\frac{2}{10}$, $\frac{2}{100}$, $\frac{2}{1000}$, &c. But, for the sake of brevity, the numerator only is expressed, like a whole number with a point on the left of it, as ·2, ·02, ·002, &c. and which must always consist of as many figures as there are ciphers in the denominator; the places between the significant figures and the point being supplied with ciphers, when necessary, as above. Consequently, the same number of figures on the right of the decimal point, has always the same denominator. Thus, the denominator of the fractions ·5000, ·0746, ·0005, is 10000. And hence, it appears, that the value of a decimal fraction is not altered by ciphers on the right hand; for ·5000 (or $\frac{5000}{10000}$) when reduced to its lowest terms is the same as ·5, each being equal to $\frac{1}{2}$. In mixed numbers the decimals are separated from the integers by a point, thus, $25\frac{2}{100}$ is written 25·02. It is also evident, that the value of decimals decreases in the same tenfold proportion from the point towards the right hand, as that of integers increases towards the left.

DECKER, relates to the rate of a ship of force, as a two-decker, a three-decker, *i.e.* carrying two entire tiers or ranges of cannon, or three such tiers.

DECKS, the planked floors of a ship, which connect the sides together, and serve as different platforms to support the artillery and lodge the men, as also to preserve the cargo from the sea and rain. As all ships are broader at the lower deck than on the next above it, and as the cannon thereof are always heaviest, it is necessary that the frame of it should be much stronger than that of the others; and for the same reason, the second or middle deck ought to be stronger than the upper deck or forecastle.

Ships of the first and second rate are furnished with three whole decks, reaching from the stem to the stern, besides a forecastle and a quarter deck, the former extending aft from the stem to the belfry, and the latter forward from the stern to the mainmast, a vacancy being left in the middle, which opens to the upper deck, and forms what is called the waist; there is yet another deck above the hinder part of the quarter deck called the poop, which also serves as a roof for the captain's cabin or couch; and another deck below the lower gun-deck called the orlop, whereon the cables are coiled and the sails stowed, &c. Other ships of the line, with 50-gun ships, and some of 40 guns, have two gun-decks and a quarter deck, a forecastle, a poop, and orlop. Frigates and sloops have one gun-deck, a half deck, and forecastle, with a spar deck below to lodge the crew, but no poop; brigs, cutters, and such small vessels, have no half deck or forecastle, and are then said to be flush fore and aft; the decks are formed of, and sustained by, the beams, the clamps, or water-ways, the carlings, the ledges, the knees, and two rows of small pillars called stanchions, &c. *See those articles.* The number of beams by which the decks of ships are supported, is often very different, according to the practice of different countries; the strength of the timber of which the beams are framed, and the services for which the ships are calculated. The deck which contains the train of a fire-ship is furnished with an equipage peculiar to itself, a description of which will be found under the article Fire-Ship. Flush deck, or deck flush fore and aft, implies a continued floor laid from stem to stem, upon one line, without any stops or intervals. Half deck, the under part of the quarter deck of a ship of war, contained between the foremost bulk head of the cabin or wardroom, and the break of the quarter deck. In the colliers of Northumberland, the steerage itself is called the half deck, and is usually the habitation of the ship's crew. The main deck is that part of the upper deck which extends from the break of the forecastle to the break of the quarter-deck; also called the waist.

DECLARATION, in Law, a written exposition of the matter of complaint, made by the plaintiff against the defendant.

DECLINATION of the Sun, of a *Star*, or a *Planet*, is its distance from the equinoctial, northward or southward. When the sun is in the equinoctial, he has no declination, and enlightens half the globe from pole to pole. As he increases in north declination he gradually shines farther over the north pole, and leaves the south pole in darkness; in a similar manner, when he has south declination he shines over the south pole, and leaves the north pole in darkness: 23° 28′ is the sun's nearest declination north or south. The declination of any heavenly body, as of a star, may be easily found by the following rule: Take the meridian altitude of the star, at any place where the latitude is known; the complement of this is the zenith distance, and is called north or south, as the star is north or south at the time of observation. Then, 1. When the latitude of the place, and zenith distance of the star, are of different kinds, namely, one north and the other south, their difference will be the declination; and it is of the same kind with the latitude, when that is the greatest of the two, otherwise it is of the contrary kind. 2. If the latitude and the zenith distance are of the same kind, *i.e.* both north, or both south, their sum is the declination; and it is of the same kind with the latitude. Accurate tables of the sun's declination are published regularly in the nautical almanacks.

Circles of Declination, are great circles of the sphere passing through the poles of the world, on which the declination is measured.

Parallels of Declination, are small circles of the sphere parallel to the equator.

Parallax, or *Refraction* of Declination, is such an arch of a meridian as is equal to the change produced in the declination by parallax or refraction, respectively.

Declination of a *Vertical Plane* or *Wall*, in Dialing, is an arch of the horizon, comprehended either between the plane and the prime vertical, when it is counted from east to west, or between the plane and the meridian, when it is counted from north to south.

DECLINATOR, an instrument for determining the declination or inclination of reclining planes.

DECLINERS, or Declining Dials, are those which cut either the plane of the prime vertical circle, or plane of the horizon, obliquely.

DECLIVITY, a sloping or oblique descent.

DECOCTION, in Pharmacy, the extracting of the virtues of simples and other drugs by boiling.

DECOMPOSITION, in Chemistry, the separation or disunion of the constituent parts of bodies.

DECORATION, in Architecture, any thing that adorns and enriches a building, church, triumphal arch, &c. as the orders of architecture, paintings, vases, festoons, scenes, &c.

DECOUPLE, in Heraldry, the same as uncoupled, or parted.

DECOY, among fowlers, a place made for catching wild-fowl. A decoy is generally made where there is a large pond surrounded with wood, and beyond that a marshy and uncultivated country: if the piece of water is not thus surrounded, it will be attended with noises and other accidents which may be expected to frighten the wild-fowl from a quiet haunt, where they mean to sleep in the day-time in security. If these noises or disturbances are wilful, it has been held that an action will lie against the disturber. As soon as the evening sets in, the decoy rises, and the wild-fowl feed during the night. If the evening is still, the noise of their wings during their flight is heard at a very great distance, and is a pleasing, though rather melancholy, sound.

The decoy ducks are fed with hemp-seed, which is thrown over the screens in small quantities, to bring them forwards into the pipes or canals, and to allure the wild-fowl to follow, as this seed is so light as to float. There are several pipes, as they are called, which lead up a narrow ditch that closes at last with a funnel-net. Over these pipes (which grow narrower from their first entrance) is a continued arch of netting suspended on hoops. It is necessary to have a pipe or ditch for almost every wind that can blow, as upon this circumstance it depends which pipe the fowl will take to; and the decoy-man always keeps on the leeward side of the ducks, to prevent his scent reaching their sagacious nostrils. All along each pipe, at intervals, are placed screens made of reeds, which are so situated that it is impossible the wild-fowl should see the decoy-man before they have passed on towards the end of the pipe, where the purse-net is placed. The inducement to wild-fowl to go up one of these pipes is, because the decoy ducks, trained to this, lead the way, either after hearing the whistle of the decoy-man, or enticed by the hemp-seed; the latter will dive under water, whilst the wild-fowl fly on, and are taken in the purse. It often happens, however, that the wild-fowl are in such a state of sleepiness and dozing, that they will not follow the decoy ducks. Use is then generally made of a dog that is taught his lesson: he passes backwards and forwards between the reed screens (in which are little holes, both for the decoy-man to see, and the little dog to pass through;) this attracts the eye of the wild-fowl, who, not choosing to be interrupted, advance towards the small and contemptible animal, that they may drive him away. The dog all the time, by the direction of the decoy-man, plays among the screens of reeds, nearer and nearer the purse-net; till at last, perhaps, the decoy-man appears behind a screen, and the wild-fowl not daring to pass by him in return, nor being able to escape upwards on account of the net-covering, rush on into the purse-net. Sometimes the dog will not attract their attention if a red handkerchief, or something very singular, is not put about him.—Watkins' *Cyclopædia.*

DECOY, in Military affairs, a stratagem to carry off the enemy's horses in a foraging party, or from pasture. The word is also used to denote a stratagem employed by a small ship of war, to betray a vessel of the enemy within reach.

DECREMENT, in Heraldry, the wane of the moon from the full to the new, and when borne in coat armour, faces to the left side of the escutcheon, as that luminary does to the right side when in the increment.

DECREPITATION, in Chemistry, a term applied to the crackling noise of salts exposed to heat, by which they are quickly split. It takes place in those salts that have little water of crystallization, the increased temperature converting that small quantity into vapour, by which the crystals are suddenly burst. Common salt affords a good example of decrepitation, and when used as a flux should be previously decrepitated.

DEDIMUS Potestatem, in Law, a commission granted to one or more persons, to forward and despatch some act appertaing to a judge, or some court.

DEED, a written contract sealed and delivered. It must be written before the sealing and delivery, otherwise it is no deed; and after it is executed by the parties, nothing can be added, and therefore, if a deed is sealed and delivered with a blank left for the sum, which the obligee fills up after sealing and delivery, this will make the deed void.

DEEP SEA-LINE, or Dip Sea-Line, in the sea-language, a small line to sound with; some a hundred and fifty fathoms long, with a plummet hollow at the head, and tallow put into it, to bring up stones, gravel, sand, shells, and the like, from the bottom, to know the differences of the ground.

DEEP WAISTED, the distinguishing fabric of a ship's decks, when the quarter deck and forecastle are elevated from four to six feet above the level of the upper or main deck, so as to leave a vacant space, called the waist, on the middle of the upper deck.

DE FACTO, something actually fact, in contradistinction to *de jure*, where a thing is only so in justice, as a king *de facto* is a person in possession of a crown, but without a legal right to the same; and a king *de jure* is he who has just right to the crown, though he is out of possession.

DEFAMATION, the offence of speaking slanderous words of another; and where any person circulates any report injurious to the credit or character of another, the party injured may bring an action to recover damages proportioned to the injury he has sustained; but it is incumbent upon the party to prove that he has sustained an injury, to entitle him to damages. In some cases, however, as for words spoken which, by law, are in themselves actionable, as calling a tradesman a bankrupt, a cheat, or swindler, &c. there is no occasion to prove any particular damage, but the plaintiff must be particularly attentive to state words precisely as they were spoken, otherwise he will be nonsuited.

DEFEASANCE, in Law, a condition relating to a deed; as to a recognizance or statute, which being performed by the recognizor, the deed is defeated, and made void, as if it had never been done.

DEFENCE, in Law, a plea made by the defendant after the plaintiff's declaration, *viz.* that he defends all the wrong, force, and damages, where and when he ought, &c.

DEFENDER of the Faith, a peculiar title given to the king of England by pope Leo the Tenth, to king Henry the Eighth, for writing against Martin Luther in behalf of the Church of Rome, then accounted *domicilium fidei catholicæ.*

DEFICIENT Numbers, in Arithmetic, those whose parts or multiples added together fall short of the integer, of which they are the parts; such is 8, its parts, 1, 2, 4, making only 7.

DEFILE, in Military affairs, a narrow passage through which a company of horse and foot can pass only by making a small front, so that the enemy may take an opportunity to charge them with so much the more advantage, as those in the front and rear cannot come to the relief of one another.

DEFINITION, an enumeration or specification of the simple ideas of which a compound idea consists, in order to ascertain its nature and character.

Definition, in Rhetoric, a short comprehensive explanation.—The special rules for a good definition are, 1. It must be adequate, that is, it must agree to all the particular species or individuals included under the same idea. 2. It must be proper, and peculiar to the thing defined. These rules being observed, will render a definition reciprocal with the thing defined, that is, the definition may be used in its place; or they may be mutually affirmed concerning each other. 3. A definition should be clear and plain; no word should be used which has any difficulty in it. 4. A definition should be short, without tautology or superfluous words. 5. Neither the thing defined, nor a synonymous name, should make any part of the definition. See the author's Grammar of Logic and Intellectual Philosophy.

DEFLAGRATION, in Chemistry, the act of burning two or more substances together, as charcoal and nitre.

DEFLECTION, the turning any thing aside from its former course by some adventitious or external cause. The word is often applied to the tendency of a ship from her true course, by currents, &c. which deflect or turn her out of her right way.

Deflection of the *Rays* of *Light*, is a property which Dr. Hook observed in 1674-5, and read an account of before the Royal Society, March 18, the same year. He says, he found it different from both reflection and refraction; and that it was made towards the surface of the opacous body perpendicularly. This is the same property which Sir Isaac Newton calls inflection. It is called by others diffraction.

DEFLECTIVE Forces, are those forces which act upon a moving body in a direction different from that of its actual course, in consequence of which the body is deflected, or turned, or drawn aside, from the direction in which it is moving. Such is the attractive force of the sun upon the earth in its orbit.

DEFOLIATION, in Botany, the fall of the leaves; a term opposed to frondescentia, the annual renovation of the leaves, produced by the unfolding of the buds in spring. Most plants in cold and temperate climates shed their leaves every year; this happens in autumn, and is generally announced by the flowering of the common meadow saffron. The term is only applied to trees and shrubs; for herbs perish down to the root every year, losing stem, leaves, and all.

DEFORCEMENT, in Law, the casting any one out of his land, or a withholding of lands and tenements by force from the right owner.

DEGLUTITION, in Medicine, the act of swallowing the food, performed by means of the tongue driving the aliment into the œsophagus, which, by the contraction of the sphincter, protrudes the contents downwards.

DEGRADATION, in Painting, expresses the lessening the appearance of distant objects in a landscape, in the same manner as they would appear to an eye placed at that distance from them.

DEGREE, in Algebra, a term applied to equations, to distinguish the highest power of the unknown quantity. Thus, if the index of that power be 3 or 4, the equation is respectively of the 3d or 4th degree.

Degree, in Geometry or Trigonometry, is the 360th part of the circumference of any circle. Every circle being considered as divided into 360 parts, called degrees, which are marked by a small ° near the top of the figure, thus, 45° is 45 degrees The degree is subdivided into 60 smaller parts, called minutes, the minute into 60 others, called seconds; the second into 60 thirds, &c. Thus 45° 12′ 20″, are 45 degrees, 12 minutes, 20 seconds.

The magnitude or quantity of angles is accounted in degrees; for because of the uniform curvature of a circle in all its parts, equal angles at the centre are subtended by equal arcs, and by similar arcs in peripheries of different diameters; and an angle is said to be of so many degrees as are contained in the arc of any circle comprehended between the legs of the angle, and having the angular point for its centre. Thus we say, an angle of 90°, or of 45° 24′. It is also usual to say, such a star is elevated so many degrees above the horizon, or declines so many degrees from the equator; or such a town is situated so many degrees of latitude or longitude. A sign of the ecliptic or zodiac contains 30 degrees.

Degree of *Latitude*, is the space or distance on the meridian through which an observer must move, to vary his latitude by one degree, or to increase or diminish the distance of a star from the zenith by one degree; and which, on the supposition of the perfect sphericity of the earth, is the 360th part of the meridian. The quantity of a degree of a meridian, or other great circle, on the surface of the earth, is variously determined by different observers, and the methods made use of are also various; and, therefore, without entering into all the histories of this undertaking, we shall present our readers with the following

Table *of the different Lengths of a Degree, as measured in various Parts of the Earth, the Time of its Measurement, the Latitude of its Middle Point, &c.*

DATE.	LATITUDE.	Extent in English Miles & Decimals.	MEASURES.	COUNTRIES.
1525	49° 20½′ N″	68·763	M. Fernel	France.
1620	52 4 N.	66· 91	Snellius	Holland.
1635	53 15 N.	69·545	Norwood	England.
1644		75·066	Riccioli	Italy.
1669	49 22 N.	68·945	Picard	France.
1718		69·119	Cassini	
1737	66 20 N.	69·403	Maupertuis,&c...	Lapland.
	49 22 N.	69·121	Cassini&LaCaille	France.
1740	45 00 N.	69·092		
1744	0 0	68·751	Juan and Ulloa..	Peru.
		68·732	Bouguer	
		68·713	Condamine......	
1752	33 18½ S.	69·076	La Caille	Cape of Good Hope.
1755	43 0 N.	68·998	Boscovich......	Italy.
1761	44 41 N.	69·061	Beccaria	
1766	47 40 N.	69·142	Leisganig	Germany.
1768	39 12 N.	68·893	Mason and Dixon	America.
1802	51 29 54½ N.	69·146	Lt.-Col. Mudge .	England.
1803	66 20½ N.	69·292	Swanberg, &c...	Lapland.
	12 32 N.	68·743	Lambton	Misore.
1808	44 52½ N.	68·769	Biot, Arago, &c.	France.

Ellipticities of the Earth, *expressed in Parts of its Equatorial Diameter.*

AUTHORS.	Ellipticities.	PRINCIPLES.
Huyghens, ...	$\frac{1}{379}$	Theory of gravity.
Newton, ...	$\frac{1}{230}$	
	$\frac{1}{314}$	
Maupertuis, &c.	$\frac{1}{129}$	Mensuration of arcs.
	$\frac{1}{213}$	
Swanberg, ...	$\frac{1}{323.065}$	
Clairault,.......	$\frac{1}{11\cdot35}$	Rotatory motion.
	$\frac{1}{337}$	Vibrations of the pendulum.
Treisnsoker,....	$\frac{1}{329}$	Occultations of the fixed stars.
Laplace,.......	$\frac{1}{331}$	Precession and nutation.
	$\frac{1}{305}$	Theory of the moon.

Degree of *Longitude*, is the space between two meridians that make an angle of 1° with each other at the poles; the quantity or length of which is variable, according to the latitude, being every where as the cosine of the latitude, *viz.* as the cosine of one latitude is to the cosine of another, so is the length of a degree in the former latitude to that in the latter, on the supposition that the earth is spherical. But taking the earth as a spheroid, the degree of longitude may be found in any given latitude L, by saying. 1. As the equatorial diameter is to the polar, so is tang. 90° — L, to tang. of an angle A; then, 2. As radius is to sine of A, so is the length of a degree of the equator to the length of a degree on the parallel of the given latitude. From these principles is the following Table computed, for expressing the length of a degree of longitude in different latitudes, supposing the earth to possess a perfect sphericity.

Deg. Lat.	English Miles.	Deg. Lat.	English Miles.	Deg. Lat.	English Miles.	Deg. Lat.	English Miles.	Deg. Lat.	English Miles.
0	69·07	20	64·81	40	52·85	60	34·50	80	11·98
1	69·06	21	64·42	41	52·07	61	33·45	81	10·79
2	69·03	22	63·97	42	51·27	62	32·40	82	9·59
3	68·97	23	63·51	43	50·46	63	31·33	83	8·41
4	68·90	24	63·03	44	49·63	64	30·24	84	7·21
5	68·81	25	62·53	45	48·74	65	29·15	85	6·09
6	68·62	26	62·02	46	47·93	66	28·06	86	4·81
7	68·48	27	61·48	47	47·06	67	26·96	87	3·61
8	68·31	28	60·93	48	46·16	68	25·85	88	2·41
9	68·15	29	60·35	49	45·26	69	24·73	89	1·21
10	67·95	30	59·75	50	44·35	70	23·60	90	0·00
11	67·73	31	59·13	51	43·42	71	22·47	—	——
12	67·48	32	58·51	52	43·48	72	21·32	..	....
13	67·21	33	57·87	53	41·53	73	20·17	..	....
14	66·95	34	57·20	54	40·56	74	19·02	..	....
15	66·65	35	56·51	55	39·58	75	17·86	..	....
16	66·31	36	55·81	56	38·58	76	16·70	..	....
17	65·98	37	55·10	57	37·58	77	15·52	..	....
18	65·62	38	54·37	58	36·57	78	14·35	..	....
19	65·24	39	53·62	59	35·54	79	13·17	..	....

Degree, in Universities, denotes a quality conferred on the students or members thereof, as a testimony of their proficiency in the arts or sciences, and entitling them to certain privileges. The degrees are much the same in all universities, but the laws thereof, and the previous discipline or exercise differ. The degrees are, Bachelor, Master, and Doctor; instead of which last, in some foreign universities, they have Licentiate.

DEINCLINERS, in Dialing, are those dials which both decline and incline or recline at the same time.

DEISTS, in the modern sense of the word, persons in Christian countries, who, acknowledging all the obligations and duties of natural religion, disbelieve revealed religion. They are so called from their belief in God alone.

DELEGATES, *Court of*, is so called because the judges thereof are delegated by the king's commission under the great seal, to hear and determine appeals in the three following cases: 1. Where a sentence is given in any ecclesiastical cause by the archbishop, or his official. 2. When any sentence is given in any ecclesiastical cause in the places exempt. 3. When a sentence is given in the admiral's court, in suits civil and marine, by order of the civil law. This commission is usually filled with lords spiritual and temporal, judges of the courts at Westminster, and doctors of the civil law.

DELFT Ware, a kind of pottery covered with an enamel or white glazing, which gives it the appearance and neatness of porcelain. Some kinds of this enamelled pottery differ much from others, either in their sustaining sudden heat without breaking, or in the beauty and regularity of their forms, of their enamel, and of the painting with which they are ornamented. In general, the fine and beautiful enamelled ware, which approaches the nearest to porcelain in external appearance, is at the same time that which least resists a brisk fire. Again, those which sustain a sudden heat are coarse, and resemble common pottery. This kind of ware has its name from Delft, in Holland, where it is made in large quantities.

DELIQUESCENCE, in Chemistry, denotes the property possessed by certain bodies, of attracting moisture from the air, and thereby becoming liquid.

DELIQUIUM, in Chemistry, the dissolution or melting of a salt or calx by suspending it in a damp place under ground.

DEMESNE, signifies the king's lands, appertaining to him in property. No common person has any domains, simply understood, for we have no land (that of the crown only excepted) which is not holden of a superior, as all depends either mediately or immediately on the crown.

DEMETRIUS, a celebrated Cynic philosopher, who lived in the time of the Emperor Vespasian.

DEMI-CULVERIN, a piece of ordnance, the least of which is four one-fourth inches bore, 19 feet long, and 2000 lbs. weight. It carries a ball of four inches diameter, and of nine pounds weight, and its level range is 174 paces. A demi-culverin of the largest sort is four three-fourths inches bore, 10 one-third feet long, and weighs 3000 pounds. It carries a ball of four and a half inches diameter, weighing 12 pounds 11 ounces, point-blank 178 paces.

DEMI-LUNE, *Half Moon*, in Fortification, an outwork consisting of two faces and two flanks.

DEMISE, in Law, is applied to an estate in fee simple, fee tail, or for term of life, and so it is commonly taken in many writs.

DEMOCRACY, in Law and polity, denotes a popular government, or that where the supreme power is in the hands of the people. Such for a time were ancient Rome and Athens.

DEMOCRITUS, one of the greatest philosophers of antiquity, who flourished about 360 years before the Christian æra.

DEMOIVRE, Abraham, an eminent mathematician, was born in France, May 1667, but settled in England at the age of eighteen, where he continued to reside till his death, which happened in November 1754, in the eighty-first year of his age.

DEMONSTRATION, a certain or convincing proof of some proposition.

Demonstration, in Logic, a series of syllogisms, all the premises of which are definitions, self-evident truths, or propositions already established.

DEMURRAGE, an allowance given to the commander of a trading ship by the merchants, for having detained him longer in port than the time previously appointed for his departure.

DEMURRER, a pause or stop put to the proceedings of an action upon a point of difficulty, which must be determined by the court before any farther proceedings can be had therein. He that demurs in law confesses the facts to be true, as stated by the opposite party; but denies that by the law arising upon those facts any injury is done to the plaintiff, or that the defendant has made out a lawful excuse.

DENARIUS, in Roman antiquity, the chief silver coin among the Romans, worth in our money about 7¾*d*. As a weight, it was the seventh part of a Roman ounce.

DENDRITES, or Arborizations, an appellation given to figures of vegetables observed in fossil substances, and which are of two kinds, the one superficial, the other internal. The first are chiefly found on the surface of stones, and between the strata and the fissures of those of a calcareous nature. They are mostly brown, changing gradually to reddish yellow. The internal dendrites are of a deep black. The most esteemed sorts are those found in agates, and particularly in the sardonyx, cornelian, and other precious stones brought from the east, and which are commonly denominated Moka stones.

DENDROMETER, an instrument invented by Messrs. Duncombe and Whittel, for which they obtained a patent, and so called from its use in measuring trees. It consists of a semicircle divided into two quadrants, and graduated from the middle; and upon the diameter there hangs a plummet for fixing the instrument in a vertical position. The principal use of it is for measuring the length and diameter of any tree perpendicular or oblique to an horizontal plane, or in any situation of the place on which it rests, or of any figure, whether regular or irregular, and also the length and diameter of the boughs, by mere inspection; and the inventors of it have calculated tables, annexed to their account of the instrument itself, by the help of which the quantity of timber in a tree is obtained without calculation, or the use of the sliding rule. The dendrometer, fitted to a theodolite, may be applied to measuring the heights and distances of objects, accessible or inaccessible, whether situated in planes parallel or oblique to the plane in which the instrument is placed. It may be also used for taking all angles, whether vertical, horizontal, or oblique, in any position of the planes in which they are formed.

DENEB, an Arabic term signifying *tail*, and hence applied to the names of certain stars in the tails of some of the constellations, as Deneb Adige in the tail of the Swan.

DENIZEN. A denizen is an alien born, who has obtained letters patent whereby he is constituted an English subject. A denizen is in a middle state between an alien and a natural born or naturalized subject, partaking of the nature of both. He may take lands by porchase, or derive a title by descent through his parents or any ancestor, though they be aliens

DENOMINATOR of a Fraction, is that number written below the line, expressing the number of parts into which the unit is supposed to be divided; thus, in the fractions $\frac{5}{12}$, $\frac{a}{b}$; 12 and b are the denominators.

DENSITY, strictly speaking, denotes vicinity or closeness of particles; but in mechanical science it is used as a term of comparison, expressing the proportion of the number of equal moleculæ, or the quantity of matter in one body to the number of equal moleculæ in the same bulk of another body; density, therefore, is directly as the quantity of matter, and inversely as the magnitude of the body. Since it may be shewn experimentally, that the quantities of matter, or the masses in different bodies, are proportional to their weight, of consequence, the density of any body is directly as its weight, and inversely as its magnitude; or the inverse ratio of the magnitudes of two bodies, having experimentally equal weight (in the same place,) constitutes the ratio of their densities. No body is absolutely or perfectly full of matter, so as to have no vacuity or interstices; on the contrary, it is the opinion of Newton, that even the densest bodies, as gold, &c. contain but a small portion of matter, and a great portion of vacuity, or that they contain a great deal more pores or empty space than real substance. *See* Impenetrability.

Density of the *Earth*. The determination of the density of the earth, as compared with that of water, or any other known body, is a subject which has excited considerable interest amongst modern mathematicians, and nothing can at first sight seem more beyond the reach of human science, than the due solution of this problem, yet this has been determined, and on such principles, that if it be not correctly true, it is probably an extremely near approximation. The first idea of determining the density of the earth was suggested by M. Bouguer, in consequence of the attraction of Chimboraco, which affected his plumb-line while engaged with Condamine in measuring a degree of the meridian, near Quito, in Peru. This led to the experiments on the mountain Schehallien, in Scotland, which were carried on under the direction of Dr. Maskelyne, and afterwards submitted to calculation by Dr. Hutton, who determined the density of the earth to be to that of water, as 4½ to 1. But in consequence of the specific gravity of the mountain being assumed rather less than it ought to have been, the above result is less than the true density, as has since been shewn by Dr. Hutton and Professor Playfair, the former of whom makes it, in his corrected paper, as 99 to 20, or nearly as 5 to 1.

The same problem has been attempted on similar principles, but totally in a different manner, by the late Mr. Cavendish, who found the density of the earth to be to that of water, as 5·48 to 1. Taking a mean of all these, we have the density of the earth to that of water, as 5·24 to 1, and which, as we before observed, is probably an extremely near approximation.

Density of the *Planets*. We have seen, in the preceding part of this article, that the density of a body is directly as its mass, and reciprocally as its magnitude; therefore, any two of these being given, the third may be undetermined. Now the magnitude of the several planets, as also of the sun, being supposed known from observation, if we can determine their masses, their densities will thus also become known.

The power of attraction with which any central body acts upon another body revolving about it, is directly as the mass of the central body, and reciprocally as the square of the distance of the revolving body; and this power may be measured by the deflection of the revolving body in a given time from the direction of its tangent. Now, if we consider the earth as the central, and the moon as the revolving body, the deflection of the latter in one second is known to be $\frac{16}{3600}$ of a foot, that is, it deviates so much from the direction of its tangent in one second of time, as may be readily ascertained by computation, being equal to the versed sine of the arc described in one second. If the distance between the earth and moon had been double what it is, this deflection would have been only ¼ of the above, if the distance were only half what it is, this deflection would be four times as much, and so on, because the power of the central body is reciprocally as the square of its distance. Again, if the distance of the bodies remain the same, and the mass of the central body be doubled, the deflection will be doubled; if tripled, the deflection will be tripled, and so on; because the power of the central body is directly as its mass. Now Jupiter's first satellite revolves about that planet at the same distance as the moon does about the earth, but its deflection in one second is 256 times that of the moon; whence, the distances being equal, it follows, that the mass of Jupiter is 256 times greater than that of the earth. Had these distances not been equal, we must have found what the deflection of the moon would be at the given distance; then comparing this with that of the satellite, the mass in any other case might be determined. Having thus found the mass, and the magnitude being known, we shall have, assuming the mass of the earth as unity; as 1 divided by the magnitude of the earth, is to the mass of any planet divided by its magnitude; so is 1, the density of the earth, to the density of the planet; and in this way the density of any planet having a satellite, may be readily computed. In other cases, recourse must be had to the disturbing force, which is of a very laborious computation. The density of the sun, and the several planets, as deduced from Laplace's "System du Monde," is as follows: *viz.*

Sun,............	0·25226	Mars, ...	0·65630
Mercury,........	2·58330	Jupiter, ...	0·20093
Venus,..........	1·02100	Saturn, ...	0·10349
Earth,..........	1·00000	Uranus, ...	0·21085

DENTIFRICE, a remedy for the teeth, of which there are various kinds; generally, however, they are made of earthy substances mixed with alum. Those formed of acids are very pernicious.

DEODAND, in Law, is a forfeiture of that thing or animal which occasions the death of a human being by mischance. Where the death is purely accidental, and no blame attached to any person, the coroner's jury usually find a deodand of one shilling.

DEPARTURE, in Navigation, is the easting or westing of a ship in respect of the meridian it departed or sailed from; or it is the difference of longitude in miles either east or west, between the present meridian the ship is under, and that where the last reckoning or observation was made.

DEPOT, any place in which military stores are deposited. Also a particular place at the tail of the trenches, out of the reach of the cannon, where the troops generally assemble who are ordered to attack the outworks.

DEPRESSION OF EQUATIONS, in Algebra, is the reduction of an equation to one of lower dimensions, an operation, however, that can only be effected in particular cases, *viz.* when a certain relation has place between the roots of the equation; thus if an equation has equal roots with either like or contrary signs, or if the equation be a reciprocal one, having each pair of roots the reciprocal of each other, and in short under almost any known relation of the roots the equation may be depressed to one of lower dimensions. If an equation have two equal roots it may be depressed one degree; if three equal roots, it may be depressed two degrees, and so on; and in reciprocal equations of even dimensions, may be depressed to half the original degree; and if they are of odd dimensions, to half the original degree minus 1.

DEPRESSION OF THE POLE. When a person sails or travels towards the equator he is said to depress the pole: because as many degrees as he approaches nearer the equator, so many degrees will the pole be nearer the horizon. This arises from the spherical figure of the earth. When a star is under the horizon it is termed the depression of that star under the horizon. The altitude or depression of a star is an arch of the vertical circle, or azimuth, intercepted between the horizon and the star.

DEPRESSION, or *Dip of the Visible Horizon*, denotes its sinking or dipping below the true horizontal plane, by the observer's eye being raised above the surface of the sea; in consequence of which the observed altitude of an object is by so much too great. The following table shews the depression or dip at the horizon of the sea for different heights of the eye.

TABLE.

Height of the eye.	Dip of the horizon.		Height of the eye.	Dip of the horizon.		Height of the eye.	Dip of the horizon.	
Feet.	′	″	Feet.	′	″	Feet.	′	″
1	0	57	13	3	26	26	4	52
2	1	21	14	3	34	28	5	3
3	1	39	15	3	42	30	5	14
4	1	55	16	3	49	35	5	39
5	2	8	17	3	56	40	6	2
6	2	20	18	4	3	45	6	24
7	2	31	19	4	10	50	6	44
8	2	42	20	4	16	60	7	23
9	2	52	21	4	22	70	7	59
10	3	1	22	4	28	80	8	32
11	3	10	23	4	34	90	9	3
12	3	18	24	4	40	100	9	33

DERHAM, JOHN, an eminent philosopher and mathematician, born at Worcester in 1657, was the author of many valuable articles in the "Philosophical Transactions," &c. Derham died in 1738, at Upminster.

DERVIS, a name given to all Mohammedan monks, though of various orders. They have convents in the same manner as the monks in the Catholic and Greek churches.

DESAGULIERS, JOHN THEO. an eminent experimental philosopher, was born at Rochelle, in France, in 1683, but educated in England, where he afterwards continued to reside. He was a member of several learned societies, and made numerous communications on the subjects of *optics*, *mechanics*, &c. both to the Royal Society of London, and to the Academy of Sciences at Paris.

DESCENSION, RIGHT, the arc of the equator which descends with the sign or star below the horizon of a direct sphere; and *oblique Descension* is the arc of the equator that descends with the sun or star in an oblique sphere.

DESCENT OF BODIES, in Mechanics, is their motion or tendency towards the centre of the earth, either in a direct or oblique direction. The laws of the descent of bodies in free space are given in the article ACCELERATION, their descent along inclined planes in the article INCLINED PLANE, and in fluids under RESISTANCE. We shall, therefore, merely refer to a singular phenomenon respecting falling bodies, which is their deviation from the perpendicular, occasioned by the rotation of the earth on its axis. When the idea of the earth's motion was started by Copernicus, it was strongly objected to it, that if the earth really revolved, a stone let fall from the top of a tower ought to fall considerably to the westward of the foot of it, being, according to their notion, left behind by the motion of the earth; and the supporters of the doctrine were not then sufficiently acquainted with the composition of motion to explain away the difficulty. However, when the laws of motion became better understood, it was discovered, that the body, instead of falling to the westward of the tower, ought to fall a little to the eastward of it, in consequence of the velocity of rotation being greater at the top than at the foot of the tower; and this deviation is said to have been really detected by M. Guglielmini and M. Benzenberg, the former finding it to be equal to 8 lines in falling 241 feet, and the latter 5 lines for a fall of 262 feet. But how far experiments on such delicate subjects may be depended on, may be a matter of doubt, but of the truth of the theoretical deflection no doubt can be entertained.

DESCENT, in Heraldry, expresses the coming down of any thing from above; as, a lion *en descent* with his head towards the base points and his heels towards one of the corners of the chief, as if he were leaping down from some high place.

DESCENT, *Line of Swiftest*, is that which a body, falling by the action of gravity, describes, in the shortest time possible, from one given point to another. And this line is the arc of a cycloid, when the one point is not perpendicularly over the other.

DESCENT, in Law, is the title by which a man, on the death of his ancestor, acquires his estate by right of representation as his heir at law; and an estate so descending to the heir is in law called the inheritance.

DESIDERATUM, the desirable accomplishment of some advancement in art or science; as, the use of pendulums where there are irregular motions.

DESIGN, in Painting, the first idea of a large work drawn roughly, and on a small scale, with the intention of being executed and finished in large. *See* Drawing. In Music, design means both the invention and execution of the subject, in all its parts, and agreeably to the general order of the whole. In Manufactures, design expresses the figures with which the workman enriches his stuff or silk, and which he copies after his own drawing or the sketches of some artist. In Building, the term ichnography may be used, when by design is only meant the plan of a building, or a flat figure drawn on paper; when some side or face of the building is raised from the ground, we may use the term orthography: and when both front and sides are seen in perspective, it may be termed scenography.

DESCRIBENT, in Geometry, is the line or surface, from the motion of which, a surface, or body, is supposed to be generated or described.

DESCRIPTIVE Geometry, the name given to a species of geometry almost entirely new, and which we owe in great measure to M. Monge. When any surface whatever penetrates another, there most frequently result from their intersection curves of double curvature, the determination of which is necessary in many arts, as in groined vault-work, cutting arch-stones, wood-cutting, for ornamental work, &c. the form of which is frequently very singular and complicated: it is in the solution of problems appertaining to these subjects that descriptive geometry is especially useful.

DETACHED Pieces, in Fortification, are outworks at a distance from the body of the place; as demilunes, ravelines, bastions, &c. In Painting, the figures are well detached, when they stand free and disengaged from each other.

DETACHMENT, in Military affairs, a number of soldiers drawn out from regiments or companies equally, to be employed as the general thinks proper; whether on an attack, at a siege, or in parties to scour the country.

DETERMINATE Problem, in Geometry, that which has a limited number of answers: as the following, *viz.* To describe an isosceles triangle on a given line, whose angles at the base shall be double that at the vertex.

DETINUE, in Law, a writ which lies where any man comes to goods or chattels either by delivery or by finding, and refuses to give them up; and it lies for the detaining, when the detaining was unlawful.

DETONATION, in Chemistry, the noise and explosion which any substance makes upon the application of fire. It is also called fulmination. Hence the detonating balls, detonating powder.

DEVELOPMENT, a term in frequent use among modern algebraists, to denote the transformation of any fraction into the form of a series.

DEVELOPMENT of a Spheric Surface on a Plane, is applied to the drawing of a small portion of the earth's surface in a manner nearly spherical, by supposing the sphere circumscribed by a polyhedron, the side of which is extended upon a plane. In approximating the development of the spheric surface, there are two methods of considering the subject: one, by supposing the polyhedrous surface to consist of conic frustums, each touching the surface of the sphere in the middle; the other, by supposing the polyhedrous surface comprised of frustums of a cylinder, meeting each other in planes passing through the centre of the sphere, and intersecting each other in one common diameter as an axis; and because both the conic and cylindric surfaces are developable, the surface of the circumscribing polyhedron will also be developable, and therefore will admit of being correctly represented. Now, supposing all the sides of the figure to be equal, and increased in number at pleasure, the greater the number, the nearer will the surface of the polyhedron coincide with that of the sphere; and consequently, any portion of the developed surface of the polyhedron, will be very nearly equal and similar to the corresponding portion of the spheric surface. Each of these different methods of representing the spheric surface has its peculiar advantage and disadvantage, when applied to the art of map-making: the conic method of development is best adapted to represent countries to any extent in the difference of longitude, or round the whole circumference of the earth if required, to a certain extent in difference of latitude; and the cylindric method of development is well adapted to represent countries contained between any two parallels of latitude, but not to have any considerable difference of longitude. Of these two different projections by development, the conical projection is the most simple, and is attended with the least trouble, on account of the facility of describing the parallels of latitude in concentric circles, and the meridians in straight lines. In comparing a spherical zone to a truncated cone, in order to construct its development, we view the parallels as circles described from the summit of the cone taken as a common centre; and the meridians are right lines subjected to pass through that point. It is visible that the result will approach the nearer, in proportion as the map shall embrace less extent in latitude. This projection may vary in different ways; for it may be supposed that the cone is a tangent to the middle parallel of the map, and in consequence, exterior; or, that it may be in part inscribed in the sphere, that is to say, formed by the secants of the meridians. In the first case, the map will not be perfectly exact, except on the middle parallel, which will preserve in its development the length which it really possesses on the sphere; but the parallels placed above and beneath, will exceed those on the sphere, which are correspondent.

With respect to the application of the development of the conic surface in the construction of maps, the Rev. Patrick Murdoch proposed to substitute to the tangent cone, a cone partly inscribed and determined upon this condition, *that the part of the area comprehended in the map, should be equivalent to that of the spherical zone which it represents.*[*] Though it may be difficult, at first sight, to conceive that the surface of the globe can be represented by a part of the surface of a cone, yet this is the case in regard to D'Anville's map of Russia. You may easily form the surface of a cone, of any plain piece of paper cut into a circular form or base; and you will as easily consider, that if a cone about twice the height of the semi-diameter of the globe, were to be conceived as standing on the same base with the hemisphere, namely, on the equator, the surface of such a cone would in part lie within the surface of the globe; and then, nothing can be more natural, than to suppose that the surface of the globe at so small a distance from the surface of the cone, might be very easily projected or delineated on it; and in such a case, the projection of the countries and their bearings, distances, &c. will be very nearly the same on the surface of the included part of the cone, as on that of the globe itself; and when such a geographical conical surface is cut out and expanded, it makes the map now under consideration.

When any portion of the earth's surface is projected on a plane, or transferred to it by whatever method of description, the real dimensions, and often the figure and position of countries, are much altered and misrepresented. The particular methods of description used among geographers are so various, that we might suspect them to be faulty; but in most of their works we find these two blemishes, the linear dimensions visibly false, and the intersections of the circles oblique; so that a quadrilateral space shall often be represented by an oblique-angled rhomboid figure, whose diagonals are very far from equal; and yet, by a strange contradiction, you shall see a scale of distances inserted in such a map. The last of these blemishes is removed, and the other lessened, in some maps of P. Schenk's of Amsterdam, a "map of the Russian empire," the "Germania Critica" of the famous Professor Meyer, and a few more. In these the meridians are straight lines, converging to a point, from which, as a centre, the parallels of latitude are described, and I have given a rule for drawing such maps, under the article Maps.

---

[*] See the Editor's Treatise on the Construction of Maps, for this development, p. 113, &c.

DEVISE, or Device, in Heraldry, Painting, and Sculpture, any emblem used to represent a certain family, person, action, or quality, with a suitable motto applied in a figurative sense.

Devise, in Law, the act whereby a person bequeaths his lands or tenements to another, by his last will and testament. The person who makes this act, is called the devisor, and he in whose favour the act is made, is termed the devisee.

DEW, that condensation of vapour which we perceive on the grass of the fields, &c. and which is produced by the evaporation of moisture from the earth, both before and after sunset. Under certain circumstances, the air holds not the same quantity of water in solution, and the result is a deposition of it in aqueous particles; during day, and under the effects of electricity, definite and floating clouds are the result, and the processes of rain often commence; but in fine weather, in the evening, the vapour plane being destroyed, the vapour so deposited precipitates down in dew. During the heat of the day a great quantity of vapour is thrown into the atmosphere from the surface of the earth and waters. When the evening returns, if the vapour has not been carried off in part by currents, it will often happen that more remains diffused in the general atmosphere than the temperature of the night will permit to subsist under the full pressure of the aqueous atmosphere. A decomposition of the latter then commences, and is continued until the general temperature and aqueous pressure arrive at an equilibrium, or until the returning sun puts an end to the process. Dew appears only on calm and clear nights: very little is ever deposited in opposite circumstances, and little only when the clouds are very high. It is never seen on nights both cloudy and windy; and if in the course of the night the weather, from being serene, should become dark and stormy, dew which had been deposited will disappear. In calm weather, if the sky be partially covered with clouds, more dew will appear than if it were entirely uncovered.

DIABETES, in Physic, an excessive discharge of urine, which comes away crude, and exceeds the quantity of liquids drank.

DIACAUSTIC CURVE, a species of the caustic curves formed by refraction.

DIACOUSTICS, or Diaphonics, the consideration of the properties of sound refracted in passing through different mediums.

DIÆRESIS, in Grammar, the division of one syllable into two, which is usually noted by two points over a letter, as aulaï instead of aulæ, dissolüenda for dissolvenda.

DIAGNOSTIC, in Medicine, a term given to those signs which indicate the present state of a disease, its nature and cause.

DIAGONAL, in Geometry, a right line drawn across a quadrilateral or other figure, whether plane or solid, from the vertex or summit of one angle to that of another; and is by some authors called the diameter, and by others the diametral of the figure. It is demonstrable, 1. That every diagonal divides a parallelogram into two equal parts. 2. That two diagonals drawn in any parallelogram bisect each other. 3. A line passing through the middle point of the diagonal of a parallelogram, divides the figure into two equal parts. 4. The diagonal of a square is incommensurable with one of its sides. 5. The sum of the squares of the two diagonals of every parallelogram is equal to the sum of the squares of the four sides. 6. In any trapezium, the sum of the squares of the four sides is equal to the sum of the squares of the two diagonals, together with four times the square of the distance between the middle points of the diagonals. 7. In any trapezium, the sum of the squares of the two diagonals is double the sum of the squares of two lines bisecting the two pairs of opposite sides. 8. In any quadrilateral inscribed in a circle, the rectangle of the two diagonals is equal to the sum of the two rectangles under the two pairs of opposite sides. 9. In every parallelopiped the sum of the squares of the four diagonals of the solid, is equal to the sum of the squares of its twelve edges. 10. In every hexaëdron, regular or not, the sum of the squares of the twelve edges, plus the sum of the squares of the twelve diagonals of the faces, is equal to three times the sum of the squares of the four diagonals which cross the solid, plus four times the sum of the squares of the six right lines which join, two by two, the middle points of those four latter diagonals. 11. In every polygon, and in every polyëdron, the sum of the squares of the lines which join, two by two, the middle points both of sides and diagonals, is the quarter of the sum of the squares of those sides and diagonals; multiplied by the number of summits of the polygon or polyëdron, diminished by two units. 12. A farther generalization of the latter property leads to the most celebrated property of the centre of gravity.

DIAGRAM, is a scheme for explanation or demonstration of any figure, or of its properties.

DIAL, or Sun-Dial, an instrument serving to measure time, by means of the shadow of the sun. The word is formed from *dies*, day, because indicating the hour of the day. The ancients also call it *sciathericum*, from its doing it by the shadow.

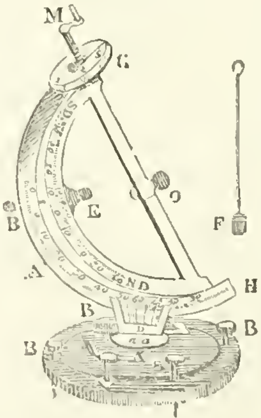
Dial is more accurately defined, a draught, or description, of certain lines on a plane, or surface of a body given, so contrived as that the shadow of a stile, or ray of the sun, passed through a hole therein, shall touch certain points at certain hours. The antiquity of dials is beyond doubt. Some attribute their invention to Anaximenes Milesius, and others to Thales. Vitruvius mentions one made by the ancient Chaldee historian Berosus, on a reclining plane, almost parallel to the equinoctial. Aristarchus Samius invented the hemispherical dial. And there were some spherical ones, with a needle for a gnomon. The discus of Aristarchus was an horizontal dial, with its limb raised up all round, to prevent the shadows stretching too far. It was late ere the Romans became acquainted with dials. The first was set up by Papirius Cursor, at or near the temple of Quirinus; but being inaccurate about 30 years after, another was brought out of Sicily by the consul M. Valerius Messala, which he placed on a pillar near the Rostrum; but neither did this shew time truly, because not made for that latitude; and after using it 99 years, Martius Philippus set up another more exact.

The diversity of sun-dials arises from the different situation of the planes, and from the different figure of the surfaces upon which they are described; whence they become denominated *equinoctial*, *horizontal*, *vertical*, *polar*, *direct*, *erect*, *declining*, *inclining*, *reclining*, &c.

Universal Dial. There are several kinds of dials called universal, because they serve for all latitudes. One of a very ingenious construction has lately been invented by Mr. G. Wright, of London. The hour circle, or arch E, and latitude arch C, are the portions of two meridian circles; one fixed, and the other moveable. The hour or dial-plate SEI at the top, is fixed to the arch C, and has an index that moves with the hour circle E; therefore the construction of this dial is perfectly similar to the construction of the meridians and hour-circles upon a common globe. The peculiar problems to be performed by this instrument are, 1. To find the latitude of any place. 2. The latitude of the place being known, to find the time by the sun and stars. 3. To find the sun or stars altitude and azimuth.

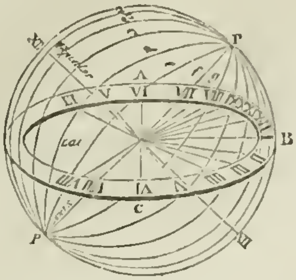
But the dial being properly adjusted, a great variety of astronomical and trigonometrical problems may be wrought upon it, which, however, our limits will not allow of detailing; we must therefore refer the reader to Jones's "Instrumental Dialing," where he will find ample information on this subject.

Universal Dial.

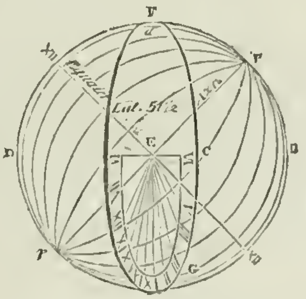


DIALING, the art of drawing dials on the surface of any given body, whether plane or curved. Dialing is wholly founded on the first motion of the heavenly bodies, and chiefly the sun; or rather on the diurnal motion of the earth; so that the elements of spherics, and spherical trigonometry, should be understood before a person advances to the theory of dialing. The edge of the plane by which the time of the day is found, is called the stile of the dial, which must be parallel to the earth's axis; and the line on which this plane is erected, is called the substile. The angle included between the substile and stile, is called the elevation or height of the stile, as in the next figure.

The principles of dialing may be aptly illustrated by the phenomena of a hollow or transparent sphere, as of glass. Thus suppose *a* P B *p* to represent the earth as transparent; and its equator as divided into 24 equal parts by so many meridian semicircles *a*, *b*, *c*, *d*, *e*, &c. one of which is the geographical meridian of any given place, as London, which it is supposed is at the point *a*; and if the hour of 12 were marked at the equator, both upon that meridian and the opposite one, and all the rest of the hours in order on the other meridians, those meridians would be the hour circles of London; because, as the sun appears to move round the earth, which is in the centre of the visible heavens, in 24 hours, he will pass from one meridian to another in an hour. Then, if the sphere had an opaque axis, as P E *p*, terminating in the poles P and *p*, the shadow of the axis, which is in the same plane with the sun, and with each meridian, would fall upon every particular meridian and hour, when the sun came to the plane of the opposite meridian, and would consequently shew the time at London, and at all other places on the same meridian. If this sphere were cut through the middle by a solid plane A B C D in the rational horizon of London, one half of the axis E P would be above the plane, and the other half below it; and if straight lines were drawn from the centre of the plane to those points where its circumference is cut by the hour circles of the sphere, those lines would be the hour lines of an horizontal dial for London; for the shadow of the axis would fall upon each particular hour line of the dial, when it fell upon the like hour circle of the sphere, as in the annexed figure.



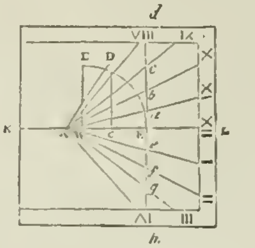
If the plane which cuts the sphere be upright, as A F C G, touching the given place, for example, London at F, and directly facing the meridian of London, it will then become the plane of an erect direct south dial; and if right lines be drawn from its centre E, to those points of its circumference where the hour circles of the sphere cut it, these will be the hour lines of a vertical or direct south dial for London, to which the hours are to be set in the figure, contrary to those on an horizontal dial; and the lower half E *p* of the axis will cast a shadow on the hour of the day in this dial, at the same time that it would fall upon the like hour circle of the sphere, if the dial plane was not in the way.



If the plane still facing the meridian, be made to incline or recline, any number of degrees, the hour circles of the sphere will still cut the edge of the plane in those points to which the hour lines must be drawn straight from the centre; and the axis of the sphere will cast a shadow on these lines at the respective hour. The like will still hold, if the plane be made to decline by any number of degrees from the meridian towards the east or west, provided the declination be less than 90 degrees, or the reclination be less than the co-latitude of the place, and the axis of the sphere will be the gnomon; otherwise, the axis will have no elevation above the plane of the dial, and cannot be a gnomon.

Thus it appears that the plane of every dial represents the plane of some great circle on the earth, and the gnomon of the earth's axis; the vertex of a right gnomon, the centre of the earth or visible heavens; and the plane of the dial is just as far from this centre as from the vertex of this stile. The earth itself, compared with its distance from the sun, is considered as a point; and, therefore, if a small sphere of glass be placed upon any part of the earth's surface, so that its axis be parallel to the axis of the earth, and the sphere have such lines upon it, and such planes within it, as above described; it will shew the hours of the day as truly as if it were placed at the earth's centre, and the shell of the earth were as transparent as glass.

To describe an Horizontal Dial, geometrically, as in the annexed figure.— Draw a meridian line K L, (*see* Meridian *Line*,) and from any part C, erect the perpendicular C D, and make the angle C A D = to the latitude of the place, and draw the line *d* E, meeting within E. Make E B = C D, and from the centre B, with radius E B, describe a quadrant E B F, which divide into six equal parts. Through E draw E *h* perpendicular to A B. From the centre B through the several subdivisions of the quadrant E F, draw the lines B *a*, B *b*, &c. meeting the line *d h* in the points *a*, *b*, *c*, &c.



From E draw the line E *h*, and set off E *e*, F *f*, E *g*, &c. respective equal to E *a*, E *b*, E *c*, &c. Through the point A draw the lines *a* XI, *b* X, *c* IX, &c. also *e* I, *f* II, *g* III, &c. which will be the several hour lines required. Then at A erect the gnomon or stile at an angle equal to the elevation of the pole, or latitude of the place, and the dial will be complete.

To compute the Angles of the Hour Lines, trigonometrically.

As Radius
Is to the sine of the latitude of the place,
So is tangent of sun's distance from the meridian,
To the tangent of the angle from the meridian on the dial.

The preceding construction and computation for the case of a horizontal dial, may be said to include the whole theory of dialing; for there is no plane, however obliquely situated with respect to any given place, but what is parallel to the horizon of some other place, and therefore, if we find that other place by a problem on the terrestrial globe, or by a trigonometrical calculation, and construct a horizontal dial for it, that dial applied to the plane where it is to serve, will be a true dial for that place.—Thus, an erect direct south dial in 51½° north latitude, would be a horizontal dial on the same meridian, 90° southward, which falls in with 38½° south latitude; but if the upright plane declines from facing the south at the given place, it would be a horizontal plane 90° from that place; but for a different longitude, which would alter the reckoning of the hours accordingly.

A Table *of the Angles which the Hour-Lines form with the Meridian on a Horizontal Dial for every half Degree of Latitude, from 50° to 59° 30′.*

LATITUDE.		A. M. I. XI.		A. M. II. X.		A. M. III. IX.		A. M. IV. VIII		A. M. V. VII.		A. M. VI. VI.	
°	′	°	′	°	′	°	′	°	′	°	′	°	′
50		11	38	23	51	37	27	53	0	70	43	90	0
50	30	11	41	24	1	37	40	53	11	70	51	90	0
51		11	46	24	10	37	51	53	24	70	58	90	0
51	30	11	51	24	19	38	4	53	36	71	6	90	0
52		11	55	24	27	38	14	53	46	71	13	90	0
52	30	12	0	24	36	38	25	53	58	71	20	90	0
53		12	5	24	45	38	37	54	8	71	27	90	0
53	30	12	9	24	54	38	48	54	19	71	34	90	0
54		12	14	25	2	38	58	54	29	71	40	90	0
54	30	12	18	25	10	39	8	54	39	71	47	90	0
55		12	23	25	19	39	19	54	49	71	53	90	0
55	30	12	28	25	27	39	29	54	59	71	59	90	0
56		12	32	25	35	39	40	55	8	72	5	90	0
56	30	12	36	25	45	39	50	55	18	72	12	90	0
57		12	40	25	51	39	59	55	27	72	17	90	0
57	30	12	44	25	58	40	9	55	37	72	22	90	0
58		12	48	26	5	40	18	55	45	72	27	90	0
58	30	12	52	26	13	40	27	55	51	72	33	90	0
59		12	56	26	20	40	36	56	2	72	30	90	0
59	30	13	0	26	27	40	45	56	10	72	44	90	0

In this table, the angles formed by the lines for V in the morning and VII in the evening, IV in the morning and VIII in the evening, &c. are not marked, because they are the same as those for VII in the morning and V in the evening, VIII in the morning and IV in the evening, only they lie on opposite sides of the VI o'clock hour-lines, as was shewn in the construction of the horizontal dial.

The use of the table may be easily comprehenced: if the place for which a horizontal dial is to be made, corresponds with any latitude in the table, the angles which the hour-lines make with the meridian may be seen at once. For example, it appears that the hour lines of XI and I must, in the latitude of 56°, make angles of 12° 32′ with the meridian. If the latitude be not contained in the table, proportional parts may be taken without any sensible error. Thus, if the latitude be 54° 15′, and the angles made by the hour-lines of XI or I be required, as it appears from the table that the increase of 30′ in the latitude, *viz.* from 54° to 54° 30′, corresponds to an increase of 4′ in the hour angle at the centre of the dial, we may infer, that an increase of 15′ will require an increase of 2′ nearly, and therefore that the angle required will be 12° 16′.

DIALING-GLOBE, an instrument of brass or wood, with a plane fitted to the horizon, and an index so contrived as to give a clear illustration of the scientific principles on which dials are constructed.

DIALING-LINES, or SCALES, are graduated lines placed on rulers, or the edges of quadrants and other instruments, for the construction of dials. These are, 1. A scale of six hours, which is a double tangent, or two lines of tangents, each of 45°, set together in the middle, and equal to the line of sines, with the declination set against the meridian altitudes in the latitude of the place. 2. A line of latitudes, fitted to the hour-scale, and made by this canon: As the radius; the chord of 90° : : the tangents of each respective degree of the line of latitudes : tangents of other arcs. And then the natural sides of these arches are the numbers, which taken from a diagonal scale of equal parts, shall graduate the divisions of the line of latitudes to any radius. The lines of hours and latitudes are general, for pricking down all dials with centres. The other scales are particular, and give the several requisites for upright declining dials by inspection. They are, 1. A line of chords. 2. A line for the substile's distance from the meridian. 3. A line for the stile's height. 4. A line of the angle of 12 and 6. 5. A line of inclination of meridians.

DIALING-SPHERE, an instrument made of brass, with several semicircles sliding over each other on a moveable horizon, to demonstrate the nature of spherical triangles, and to give the true idea of drawing dials.

DIAMETER, in Geometry, the line which, passing through the centre of a circle, or other curvilinear figure, divides it, or its respective ordinates, into equal parts.

Conjugate DIAMETER of a *Conic Section*, is a line drawn through the centre of the figure to its sides, and the shortest of the two diameters of the figure.

Transverse DIAMETER of a *Conic Section*, is a line drawn through the foci to the curve.

How to find the DIAMETER *of Shot or Shells.*—For an iron ball, whose diameter is given, supposing a nine-pounder, which is nearly four inches, say the cube root 2·08, (of nine pounds,) is to four inches, as the cube root of the given weight, is to the diameter sought. Or, if 4 be divided by 2·08, the cube root of 9, the quotient 1·923 will be the diameter of one-pound shot, which being continually multiplied by the cube root of the given weight, gives the diameter required. Or by logarithms thus: If the logarithm of 1·923, which is 2·83979, be constantly added to the third part of the logarithm of the weight, the sum will be that of the diameter. Suppose a shot to weigh 24 lbs. add the given logarithm ·283979 to ·460070, the third part of the logarithm 1·3802112 of 24, the sum ·7440494 will be the logarithm of the diameter of a shot weighing 24 pounds, which is 5·5468 inches. If the weight should be expressed by a fraction, the rule is the same; for instance, the diameter of a pound and a half ball, or three seconds, is found by adding the logarithm ·2839793 found above, to ·0586971, one-third of the logarithm of two-thirds; the sum ·3426764 will be the logarithm of the diameter required. *i. e.* 2·2013 inches.

DIAMETER of the *Planets*, &c. in Astronomy, are either real or apparent. The real diameters are the absolute measure of them in miles, &c. and their apparent diameters are the angles under which they appear to spectators on the earth, and are therefore different under different circumstances; *viz.* according as they are nearer or more remote from the earth. As these angles are very small, the diameter of the planet may be considered as part of a circle of which the earth is the centre, and they are said to contain so many minutes, seconds, &c. as is measured by that arc, and consequently the apparent diameter of a planet is in the inverse ratio of its distance. And hence again, the apparent diameters and distances being known, their real diameters thence become determined.

TABLE *of the Mean and Apparent Diameters of the* ***Planets.***

	Apparent mean diameter, as seen from the earth.	Apparent diameter, as seen from the sun.	Mean diameter in English miles.	Apparent diameter of the sun, seen from the planets.	Proportional diameter.
Sun	32′ 2″	......	882269	......	110 000
Mercury	11″·8	16″	3124	80′	·4
Venus ..	57″·9	30″	7702	46′	·9
Earth ...	....	17″·4	7916	32′	1·0
Mars ...	8″·94	10″	4398	21′	·5
Jupiter..	39″	37″	91522	6′·1	11·6
Saturn..	18″	16″	76068	3′·4	9·8
Uranus .	3″·54	4″	35112	1′·6	4 25
Moon ...	31′ 26″·5	4″·6	2160	32′	·27

DIAMOND, *see* CHEMISTRY, for the properties of the diamond. There are various kinds of diamonds, as the Cornish, Rose Arran, &c. but these are inferior to the diamonds of Brazil; and these last to the gems of India. Diamond, in the glass trade, is an instrument used for cutting glass, in which is set, in lead or silver, a crystal or gem that will cut glass.

DIAMOND, in Heraldry, expresses the black colour in the achievements of peerage.

DIAMOND *Mines* are found in Brazil, in South America; and in Golconda, Visapour, Bengal, and the island of Borneo. The diamond can only be cut and ground by itself and its own substance. To bring it to that perfection which augments its price so considerably, they begin by rubbing several against each other while rough, after having first glued them to the ends of two wooden blocks, thick enough to be held in the hand. It is this powder thus rubbed off the stones, and received in a little box for the purpose, that serves to grind and polish the stones. Diamonds are cut and polished by a mill, which turns a wheel of soft iron sprinkled over with diamond dust mixed with oil of olives. The same dust, well ground and diluted with water and vinegar, is used in the sawing of diamonds, which is performed with an iron or brass wire, as fine as a hair. Sometimes, in lieu of sawing the diamonds, they cleave them, especially if there are any large shivers in them.

The first water, in diamonds, means the greatest purity and perfection of their complexion, which ought to be that of the purest water. When diamonds fall short of this perfection, they are said to be of the second or third water, &c. till the stone may be properly called a coloured one; for it would be an impropriety to speak of an imperfectly-coloured diamond, or one that has other defects, as a stone of a bad water only.

For the valuation of diamonds of all weights, the following rule has been given. First, suppose the value of a rough diamond to be settled at £2 per carat at a medium, then to find the value of diamonds of greater weights, multiply the square of their weight by 2, and the product is the value required: *e.g.* To find the value of a rough diamond of two carats; 2 × 2 = 4, the square of the weight, which multiplied by 2, gives £8, the true value of a rough diamond of two carats. For finding the value of manufactured diamonds, we suppose half their weight to be lost in manufacturing them; and therefore, to find their value, we must multiply the square of double their weight by 2, which will give their true value in pounds. Thus, to find the value of a wrought diamond weighing two carats; we first find the square of double the weight, *viz.* 4 × 4 = 16; then 16 × 2 = 3·2. So that the true value of a wrought diamond of two carats is £32. On these principles Jeffries has constructed tables of the price of diamonds from 1 to 100 carats. The value of diamonds, however, depends so much on imagination, and not on real use, that no positive rule can be given. In the very large diamonds, Jeffries's rule will be far from the truth.—Diamond chemically analyzed, is found to consist of pure carbon, that is, charcoal.

Diamond, *Brilliant*, is that which is cut in faces at the top and bottom; and whose table, or principal face at top, is flat.

Diamond, *Rose*, is one that is quite flat underneath, with its upper part cut in many little faces, usually triangles, the uppermost of which terminates in a point.

DIANÆ ARBOR, or Arbor Lunæ, in Chemistry, the beautiful crystallizations of silver, dissolved in nitrous acid, to which some quicksilver is added; and so called from their resembling the trunk, branches, leaves, &c. of a tree.—(*See page* 53, *col.* 2.)

DIANTHUS, a genus of plants belonging to the class diandria, or hermaphrodite plants, as the clove gilliflower, carnation, pink, sweet-william, &c.

DIAPASON, in Music, an interval that expresses the *octave* of the Greeks, or a rule or scale whereby musical instrument makers adjust the pipes of organs, and cut the holes of hautboys, flutes, &c. in due proportion, for performing the tones, semitones, and concords, with precision.

DIAPHRAGM, in Anatomy, the midriff, a strong muscular substance that separates the breast and thorax from the abdomen, and thus portions off the abdominal and thoracic viscera.

DIARRHŒA, or Looseness, in Medicine, is a frequent and copious evacuation of liquid excrement by stool.

DIARY, a journal or day-book, containing an account of every day's proceedings.

DIASTOLE, in Physic, signifies the dilatation of the heart, auricles, and arteries; and stands opposed to the systole, or contraction of the same parts.

DIATESSARON, in Music, applied by the Greeks to that interval which we call a fourth; consisting of a greater tone, a lesser tone, and one greater semitone. The word is also used for the four gospels, arranged after the manner of a harmony.

DIBBLING, in Agriculture, a mode of setting corn, or other seeds, practised with advantage in places where labour is cheap; it is chiefly used for putting wheat crops into the ground. The practice of dibbling was first introduced into Norfolk, about twenty-five years ago. The method of dibbling is this: when the land is ploughed and rolled, a man with an iron dibble, of about three feet long, in each hand, walking backwards, makes two rows of holes in each furrow, at about four inches' distance from each other, and an inch or two deep. The dibbler is followed by two or three women, or children, who drop two or three grains into each hole. The field is afterwards bush-harrowed. The usual quantity of seed is from a bushel and a half to two bushels per acre, and the expense of labour about ten shillings. An experienced dibbler, with three active attendants, will plant half an acre a day, making six holes in every foot length.

DICE, among gamesters, certain cubical pieces of bone or ivory, marked with dots on each of their faces, from one to six, according to the number of faces. Sharpers have several ways of falsifying dice: 1. By sticking a hog's bristle in them so as to make them run high or low as they please. 2. By drilling and loading them with quicksilver; which cheat is found out by holding them gently by two diagonal corners; for if false the heavy sides will turn down. 3. By filing and rounding them. But all these ways fall short of the art of the dice makers; some of whom are so dexterous, that sharping gamesters will give any money for their assistance.

DIET, in Medicine, comprehends the whole regimen or rule of life, with regard to the six non-naturals; air, meats and drinks, sleep and watching, motion and rest, passions of the mind, retentions and excretions. Or it may merely imply eating and drinking, or solid aliments and liquids.

DIETETICS, the Science or Philosophy of Diets: that which teaches us to adapt particular foods to particular organs of digestion, or to particular states of the same organs; so that the greatest possible portion of nutriment may be extracted from a given quantity of nutritive matter; or a sufficient portion may be obtained with the least possible quantity of organic action and exhaustion.

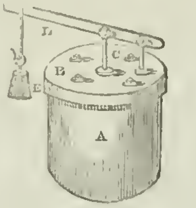
DIFFERENCE, is the remainder, after taking the less of two quantities from the greater.

Difference of *Longitude* of two places, is an arc of the equator contained between the meridians of those places.

DIFFERENTIAL, in the higher Geometry, is an infinitely small quantity, or part of quantity, so small as to be less than any assignable one, and is thus denominated, because it is frequently considered as the difference of two quantities, and as such is the foundation of the differential calculus.

Differential *Calculus*, is a method of differencing quantities, or of finding an infinitely small quantity, which being taken infinite times shall be equal to a given quantity; or it is the arithmetic of the infinitely small differences of variable quantities; and thus differs in its metaphysics from the fluxional calculus, those quantities which in the former are considered as infinitely small differences, being in the latter supposed to be the infinitely small or momentary increments of variable or flowing quantities.

DIGESTER. The digester is an instrument invented by Mr. Papin about the beginning of the last century. It is a strong vessel of copper or iron, with a cover adapted to screw on with pieces of felt or paper interposed. A valve with a small aperture is made in the cover, the stopper of which valve may be more or less loaded, either by actual weights, or by pressure from an apparatus on the principle of the steelyard. The purpose of this vessel is to prevent the loss of heat by evaporation. The solvent power of water when heated in this vessel is greatly increased. Papin's digester was constructed on the principle of mechanical pressure being necessary to elevate fluids to higher temperatures than their common boiling points.



A is the boiler; B the lid, fastened down by four screws; C a valve to allow the escape of a small portion of steam, to prevent the bursting of the apparatus; D is a notched lever, on which a weight E hangs, to prevent the valve from rising by a slight expansion of the steam. The weight is heavy according to the strength and thickness of the iron of which the digester is formed. The whole apparatus is generally made very strong, to prevent accidents. Animal bones are dissolved with great facility in these digesters, in order that the gelatine confined in them may be converted into rich soups, &c. For this purpose, they have been much used in hotels, coffee-houses, and family establishments. The heat of the water contained in this apparatus, is so intense as to melt lead.

DIGESTION, in Medicine, is the dissolution of the aliments into such minute parts as are fit to enter the lacteal vessels and circulate with the mass of blood. The food is first conveyed to the stomach, where by means of the gastric juice it is converted into chyme. The chyme passes into the intestinal canal, where it is subjected to a new process, being gradually decomposed and converted into chyle and excrementitious matter, which by means of the bile are separated from each other. The excrementitious matter is evacuated, but the chyle is absorbed by the lacteals, and conveyed to the blood vessels by the lungs.

DIGGING, among miners, the operation of freeing ore from the stratum in which it lies, where every stroke of their tools turns to account: in contradistinction to the openings made in search of such ore, which are called hatches or essay-hatches, and the operation itself, tracing of mines, or hatching.

DIGITS, or Monades, in Arithmetic, signify any integer under 10, as 1, 2, 3, 4, 5, 6, 7, 8, 9.

DIGGLES, Leonard, an English mathematician, born at Barham, in Kent, and educated at University college, Oxford, wrote a treatise on "Surveying," "Geometry," and "Prognostication everlasting of right good Effect," or, "Choice Rules to judge the Weather by Sun, Moon, and Stars," &c. He died about 1574.

Diggles, *Thomas*, son of the preceding, educated at Oxford, after which he became muster-master-general of the forces sent by queen Elizabeth to the Netherlands. He wrote some military pieces, and some on astronomy, and other subjects of mathematics. He died in 1595.

DIGIT, in Arithmetic, signifies any one of the ten numerals, 1, 2, 3, 4, 5, 6, 7, 8, 9, 0. The word comes from *digitus*, a finger; thus indicating the humble means originally employed in computations. **Digit**, is also a measure equal to three-fourths of an inch.

Digit, in Astronomy, is the measure by which we estimate the quantity of an eclipse. The diameter of the sun or moon's disc is conceived to be divided into 12 equal parts, called digits; and according to the number of those parts or digits which are obscured, so many digits are said to be eclipsed. When the luminary is wholly covered, the digits eclipsed are precisely 12; and when it is more than covered, as is frequently the case in lunar eclipses, then more than 12 digits are said to be eclipsed.

DIKE, or **Dyke**, a ditch or drain; and also a work of stone, timber, or fascines, raised to oppose the passage of the waters of the sea, a lake, river, or the like.

DILAPIDATION, is where an incumbent of a church living suffers the parsonage-house or out-houses to fall down, or be in decay for want of necessary reparations; or it is the pulling down or destroying any of the houses or buildings belonging to a spiritual living, or destroying of the woods, trees, &c., appertaining to the same; for it is said to extend to committing or suffering any wilful waste, in or upon the inheritance of the church.

DIMENSION, in Geometry, is either length, breadth, or thickness. Thus a line has only one dimension, *length;* a surface two, *length* and *breadth;* and a body or solid, *length, breadth*, and *thickness.*

Dimension of an *Equation*, or any other quantity in Algebra, is used with regard to the highest power that enters into its composition; thus an equation is said to be of one, two, three, &c. dimensions, according as it involves the simple quantity, the square, cube, &c.; so that a simple equation is of one dimension, a quadratic of two, a cubic of three, &c.

DIMINUTION, in Architecture, a contraction of the upper part of a column, by which its diameter is made less than that of the lower part.

Diminution, in Law, where the plaintiff or defendant in a writ of error, alleges, on an appeal to a superior court, that part of the record is omitted, and remains in the inferior court not certified; whereon he prays that it may be certified by certiorari.

Diminution, in Music, when there are several words, which are to make tones, and several quick motions in a cadence, several quavers, semiquavers, &c., corresponding to a crotchet or minim, as when a semibreve is divided into two minims, four crotchets, &c.

DIMINUTIVE, in Grammar, a word formed from some other, to diminish the force of it, or to signify a thing is little in its kind. Thus Hal is a diminutive of Henry.

DINOCRATES, a celebrated Macedonian architect, who flourished in the time of Alexander.

DIOCESE, the circuit of every bishop's jurisdiction. For this realm hath two sorts of divisions; one into shires or counties, in respect to the temporal state; and another into provinces, in regard to the ecclesiastical state, which provinces are divided into dioceses. The provinces are two, Canterbury and York; whereof Canterbury includes twenty-one dioceses, or sees of suffragan bishops; and York three, besides the bishopric of the Isle of Man, which was annexed to the province of York by king Henry the Eighth.

DIONÆA MUSCEPULA, or *Venus's Fly-Trap*, in Botany, a sensitive plant, in the construction of which nature seems to have had some view towards its nourishment, in forming the upper joint of its leaf like a machine to catch food; and placing upon the middle of it the bait for the insect that becomes its prey. The plant is of the monogynia order, in the decandria class. It grows in America, in wet shady places, and flowers in July and August; the glands of those exposed to the sun are of a beautiful red colour, but those in the shade are of a pale green. The roots are squamous, sending forth few fibres, and are perennial. The leaves are numerous, and placed in a circular order, jointed and succulent; the upper joints consist of two lobes, of a semi-oval form, with the margins furnished with stiff hairs, which lock in each other when they close; the upper surfaces of these lobes are covered with red glands, each of which appears, when highly magnified, like a compressed arbutus berry. The stalk is about six inches high, round, smooth, and without leaves, ending in a spike of flowers, milk-white, and standing on footstalks, at the bottom of which is a little painted bractea or flower-leaf.

DIONYSIUS, an ancient geographer, supposed to have flourished in the time of the first Augustus Cæsar.

DIOPHANTINE Analysis, or *Problems*, in Algebra, are certain questions relating to square, cube, &c. numbers, and rational right-angled triangles; the properties of which were first discussed by Diophantus, in his "Arithmetic."

DIOPTRICS, or **Anaclastics**, the doctrine of refracted vision, which investigates and explains the effects of light refracted by passing through different mediums, as air, water, glass, &c. and particularly lenses. *See* Refraction and Lens.

DIP of the Horizon, is an allowance made in all astronomical observations of altitude for the height of the eye above the level of the sea.

DIPHTHONG, in Grammar, a double vowel, or the mixture of two vowels pronounced together so as to make one syllable.

DIPLOMATICS, a word derived from diploma, in this instance signifying the king's letters patent, for the immediate expediting of an ambassador or envoy to a foreign court. The art of diplomatics has been cultivated with great assiduity by every nation in Europe for very many years past, and men experienced in political history, of engaging manners, and possessing a considerable share of duplicity, have always been selected by each to practise it.

DIPPING, among Miners, signifies the interruption of a vein of ore; an accident that gives them a great deal of trouble before they can discover the ore again.

DIPPING NEEDLE, or **Inclinatory Needle**, a magnetical needle, so hung, as that, instead of playing horizontally, and pointing north and south, one end dips or inclines to the horizon, and the other points to a certain height above it, as shewn in the following results of several of the most accurate experiments that have yet been made on this subject.

LATITUDES North.	LONGITUDES East.	DIP of the NORTH END of the NEEDLE.	DATES of Observation.
53° 55′	193° 39	69° 10′	1778
49 36	233 10	72 29	
	West.		
52 24	83 30	79 17	1775
41 5	8 10	71 34	1776
38 53	12 1	70 30	
34 57	14 8	66 12	
29 18	16 7	62 17	
24 24	18 11	59 0	
20 47	19 36	56 15	
15 8	23 38	51 0	
12 1	23 35	48 26	
10 0	22 52	41 12	
5 2	20 10	37 25	
South.			
0 3	27 38	30 3	
4 40	30 34	22 15	
7 3	33 21	17 57	
11 25	31 24	9 15	
	East.	*South and below.*	
16 45	208 12	29 28	
19 28	204 11	41 0	
21 8	185 0	39 1	1777
35 55	18 20	45 37	1774
41 5	174 13	63 49	1777
45 47	166 18	70 5	1773

The inventor of this instrument was one Robert Norman, a compass maker, of Wapping, about the year 1576.

Some have endeavoured to find the latitude and longitude of places by means of the dipping needle, particularly Burrowes, Gilbert, Bond, Whiston, &c.; but as nothing of importance followed from their attempts, it would be useless to enter upon any explanation of their particular methods in this place. But the following general rule may be adopted:—In order to find the longitude or latitude by the dipping needle. If the lines of equal dip, below the horizon, be drawn on maps, or sea charts, from good observations it will be easy, from the longitude known, to find the latitude; and from the latitude known, to find the longitude. Suppose, for example, you were travelling or sailing along the meridian of London, and found the angle of dip, with a needle of one foot, to be 75°, the chart will shew, that this meridian and the line of dip meet in the latitude of 53° 11′; which therefore is the latitude sought. Or suppose you were travelling or sailing along the parallel of London, *i.e.* in 51° 32′ north latitude, and you find the angle of dip to be 74°. This parallel, and the line of this dip will meet in the map in 1° 46′ of east longitude from London, which is therefore the longitude sought.

DIRECT, a term frequently used in Arithmetic, Astronomy, Optics, &c. to denote some peculiar condition or circumstance, as *Direct Proportion, Ratio, Rays, Vision*, &c. for which see the respective substances.

DIRECT, in Astronomy. *See* CONSEQUENTIA.

DIRECT *Dial*, is one which points directly to any one of the four cardinal points, and is hence called *direct east, west, north*, or *south dial*, according to the point towards which it is directed.

DIRECT *Sphere*. *See* RIGHT *Sphere*.

DIRECTION, in Astronomy, the motion and other phenomena of a planet when direct.

Line of DIRECTION, in Gunnery, is the direct line in which the piece is pointed; and, in Mechanics, the same term implies the line in which a body moves, or in which a force is applied. When two conspiring forces act on a body at the same time, the angle included between the lines of their direction is called the *angle of direction*.

Number of DIRECTION, in the Calendar, is the number of days that Septuagesima Sunday falls after the seventeenth day of January.

Quantity of DIRECTION, in Mechanics, is a term sometimes used to denote what is more commonly called *Momentum*.

DIRECTLY, is used in nearly the same sense as direct; thus we say, quantities are directly proportional, which is only another way of stating them to be in direct proportion; and in Mechanics, one body is said to impinge directly upon another, when the former strikes the latter perpendicular to its surface.

DIRECTRIX, in the Conic Sections, is a certain right line perpendicular to the axis of the curve, and frequently referred to in treating of the properties of those figures, from the description of them in plano.

DIRECTRIX, or *Dirigent*, is also that line or plane along which another line or plane is supposed to move, in the generation of a surface or solid.

DISABLED, the state of a ship when, by the loss of her masts, sails, yards, or rigging, by springing a leak, receiving some fracture in the hull, or other disaster, she is rendered incapable of prosecuting her voyage without great difficulty and danger.

DISC, the face of the sun or moon, as either luminary appears to the naked eye.

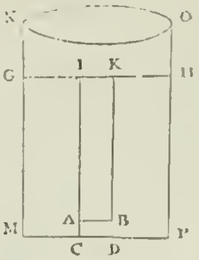
DISC, in Optics, is the width of the aperture of telescope glasses, whether plane, convex, concave, &c.

DISCHARGE OF FLUIDS, through apertures in the sides and bottoms of vessels, is a subject which has engaged the attention both of theorists and experimentalists; and may be considered under either point of view. We shall first state the principal propositions in the theoretical part of the subject, and then give some of the most remarkable and accurate experiments, by Bossut, Venturi, Eytelwein, Vince, Young, Leslie, &c.

1. If a fluid runs through a pipe or tube of an uniform shape, equal quantities of it will pass through every parallel section of the tube. This is evident, because the same quantity of fluid must pass through the same section in the same time. But though the water runs with the same velocity through every section of the tube, it does not run with equal velocity through every part of the same section. Its motion is swiftest towards the middle, and slower towards the sides of the tube, where it is retarded by friction.

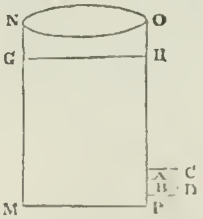
2. If a fluid runs through a tube or pipe, kept constantly full by means of a proper supply, but which is not of uniform shape; then the velocity of the fluids, in different sections, will be inversely as the areas of the sections. For since the tube is always full, the same quantity of water must pass through every section of it in the same time; but if the area of one section be half as great as the area of another section, the same quantity of water cannot pass through both sections at the same time, unless it pass through the former section with double the velocity with which it passes through the latter. If the area of the former section be one-third, or one fifth, of the area of the latter, the same quantity of water must pass through the former with a velocity which is three times, or five times, the velocity with which it passes through the latter. Hence the velocities must be inversely as the areas of the sections.

3. If a fluid, flowing through a small orifice in the bottom of a vessel, be kept constantly full by an uniform supply at the top, the velocity of the discharging fluid will be equal to that acquired by a heavy body in falling freely through the height of the surface of the fluid above the orifice.



Let M N O P represent a vessel filled with a non-elastic fluid up to the level of I K; M P, the bottom in which is the aperture C D (very small in comparison with M P), C I K D the column of the fluid standing directly above the aperture, and C A B D the lowest lamina of the fluid immediately contiguous to the aperture. Also let v denote the velocity which a heavy body would acquire in falling freely through B D, the height of the lamina; and V the velocity acquired by the same lamina during its descent through the same space until it is discharged by the pressure of the column C I K D. If we suppose the lowest lamina of fluid A C D B, to fall as a heavy body through the height B D, its moving orifice will be its own weight. Again, suppose it to be accelerated by its own weight, together with the pressure of the ambient fluid, about the column C I K D; *viz.* by the weight of the column C I K D through the same space; that is, while it is accelerated from quiescence until it is actually discharged: then the velocity in the former case will be to that in the latter, as the moving forces and the times in which they act directly, and the quantities of matter moved inversely. But the moving forces are to each other, as the heights B D and K D; the times in which they act are inversely as the velocities, the space through which the body is accelerated being given; and the quantities of matter moved are equal; therefore $v : V :: \frac{BD}{v} : \frac{KD}{V}$; whence $v^2 : V^2 :: BD : KD$, or $v : V :: \sqrt{BD} : \sqrt{BD}$.

Now v is the velocity which a heavy body would actually acquire in falling through the space B D; consequently V, the velocity of the discharging fluid, is that which a heavy body would acquire in falling through K D, the whole altitude of the fluid above the orifice.



4. In the same manner it may be shown that if a pipe be inserted horizontally in the vessel M N O P the plate of fluid A C B will be discharged with the same velocity as before (if its centre of pressure be of the same depth), whatever be the thickness of the plate; this velocity not depending upon a continual acceleration through the length of the tube, otherwise the effluent fluid could not attain its full velocity, until a column had been discharged whose base is equal to the orifice, and height equal to the length of the tube; whereas we find by experience, that this full velocity can be attained by the thinnest plate which can be let escape from the aperture.

5. The velocities and quantities discharged at different depths, are as the square roots of the depths.

6. The quantity run out in any time is equal to a cylinder, or prism, whose base is the area of the orifice, and its altitudes the space described in that time by the velocity acquired by falling through the height of the fluid. So that if h denote the height of the fluid, a the area of the aperture, $g = 32\frac{1}{2}\ \frac{1}{8}$th feet, or 386 inches, and t the time of efflux, we shall have, for the quantity discharged, $Q = a\, t \sqrt{2 g h}$,—or,

When a and h are expressed in feet, $Q = 8\cdot0208\, a\, t \sqrt{h}$ feet.

When a and h are expressed in inches, $Q = 27\cdot7387\, a\, t \sqrt{h}$ inch.

If the orifice is a circle whose diameter is d, then $0\cdot785398\, d^2$ must be substituted for a;

And when d and h are expressed in feet, $Q = 6\cdot29952\, d \sqrt{h}$ feet.

When d and h are expressed in inches, $Q = 21\cdot78592\, d\ 1^2 \sqrt{h}$ inches.

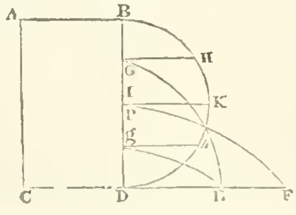
And from either of these it will be easy to find either a, t, or h, when the other three quantities are given.

7. The force with which the effluent water impinges against any quiescent body, is proportional to the altitude of the fluid above the orifice. For the force is as the velocity multiplied by the quantity of matter; but the quantity discharged, in a given time, is as the velocity; therefore the force is as the square of the velocity; that is, by the demonstration of the proposition, (art. 3.) as the height of the fluid.

8. The water spouts out with the same velocity whether it be downwards, or upwards, or sideways; because the pressure of fluids is the same, in all directions, at the same depth.

9. When a vessel is left to discharge itself gradually, through an orifice in its bottom, if the area of the section parallel to the bottom be every where the same, the velocity of the surface of the fluid, and consequently the velocity of the efflux, will be uniformly retarded. For (by prop. 2.) the velocity of the descending surface is to the velocity at the surface, as the area of the orifice to the area of the surface, which is a constant ratio; consequently, the velocity of the descending surface varies as the velocity at the orifice, or as the square root of h; that is, the velocity of the descending surface varies, as the square root of the space which it has to describe: so that this exactly corresponds with the case of a body projected perpendicularly upwards, where the velocity is as the square root of the space to be described: whence, as the retarding force is constant in the instance referred to, it must also be constant in the case before us, and the retardation uniform. From this comparison we deduce the following obvious corollaries. The quantities of water in a prismatic vessel, discharged through an aperture in the bottom, decrease in equal times; as the series of odd numbers 1, 3, 5, 7, 9, &c. taken in an inverted order. The quantity of water contained in an upright prismatic vessel, is half that which would be discharged in the time of the entire gradual evacuation of the vessel, if the water be kept always at the same altitude.

10. If upon the altitude of the fluid in a vessel, as a diameter, we describe a semi-circle, the horizontal space described by the fluid spouting from a vertical orifice, at any point in the diameter, will be as the ordinate of the circle drawn from that point; the horizontal space being measured on the plane of the bottom of the vessel. When the aperture is vertical, and indefinitely small (as supposed here), the fluid will spout out horizontally with the velocity due to the altitude of the fluid above the orifice (by prop. 3); and this velocity, combined with the perpendicular velocity arising from the action of gravity, will cause every particle, and consequently the whole jet, to describe the curve of a parabola. Now the velocity with which the fluid is expelled from any hole, as G, is such as if uniformly preserved would carry a particle through a space equal to 2 B G, in the time of the fall through B G; but, after quitting the orifice, it describes the parabolic curve, and arrives at the horizontal plane C F in the same time as a body would fall freely through G D; so that to find the distance D E, since the times are as the roots of the spaces, we have this analogy $\sqrt{GB} : \sqrt{GD} :: 2BG : DE = \frac{2BG . \sqrt{GD}}{\sqrt{GB}} = 2\sqrt{BG . GD} = 2GH$, by the nature of the circle. And the same will hold with respect to any other point in B D. If the apertures be made at equal distances from the top and bottom of the vessel (kept full of fluid), the horizontal distances to which the water will spout from these apertures will be equal. For when $Dg = BG$, we shall have $2\sqrt{Bg . gD} = 2\sqrt{BG . GD}$, and consequently D E the same in both cases. When the orifice is at the point bisecting the altitude of the fluid in the vessel, the fluid will spout to the greatest distance on the horizontal plane; and that distance, if measured on the plane of the bottom of the vessel, will be equal to the depth of the fluid in it. For I K, the ordinate from the centre I, is the greatest which can be drawn in the semi-circle, and D F, which is $= 2\,IK$, is then $= 2\,BI = BD$.



We have already extended this article, and therefore must be very brief in stating the results of the principal experiments that illustrate this interesting inquiry. With respect to the quantity of fluid discharged, Bossut's experiments, made with peculiar accuracy, demand particular notice. They are expressed in the following table, which exhibits the quantity of fluid discharged through orifices pierced in thin plates; in measures of the Paris foot royal, which is to the English foot, as 1066 to 1000.

Constant Altitude of the Water in the Reservoir above the Aperture, in Paris Feet.	Theoretical Discharges in one Minute through a circular Aperture of Tin, expressed in Cubic Inches.	Real Discharges in the Time through the same Orifice, expressed also in Cubic Inches.
1	4381	2722
2	6196	3816
3	7589	4710
4	8763	5436
5	9797	6075
6	10732	6654
7	11592	7183
8	12392	7672
9	13144	8135
10	13855	8574
11	14530	8990
12	15180	9384
13	15797	9764
14	16393	10130
15	16968	10472

The following is another set of experiments made by the same author with different apertures; in which the water was kept constantly at the altitude of eleven feet, eight inches, ten lines, from the centre of each aperture

Experiments.	Cubic Inches furnished in One Minute.
1. Horizontal circular aperture, 6 lines diameter,..	2311
2. Circular horizontal aperture, 1 inch diameter,..	9281
3. Circular horizontal aperture, 2 inch diameter,..	37203
4. Rectangular horizontal aperture, 1 in. 3 lines,..	2933
5. Square horizontal aperture, 1 inch, ...	11817
6. Square horizontal aperture, 2 inches,..........	47361
Constant height of water 9 feet.	
7. Lateral circular aperture, 6 lines diameter,....	2018
8. Lateral circular aperture, 1 inch diameter, ...	8135
Constant height of water 4 feet.	
9. Lateral circular aperture, 6 lines diameter, ...	1353
10. Lateral circular aperture, 1 inch diameter, ...	5436
Constant height of water 7 lines.	
11. Lateral and circular orifice, 1 inch diameter, ..	628

From these experiments we may derive the following deductions; *viz.*

1. The quantities of fluid discharged, in equal times, from different sized apertures, the altitude of the fluids being the same, are to each other nearly as the areas of the apertures.

2. The quantities of water discharged, in equal times, by the same aperture, with different altitudes of water in the reservoir, are nearly as the square roots of the corresponding altitudes of the water in the reservoir above the centre of the aperture.

3. That, in general, the quantities of water discharged, in the same time, by different apertures, and under unequal altitudes of the water in the reservoir, are to each other in a compound ratio of the areas of the apertures, and the square roots of the altitudes.

4. That on account of the friction, the smallest apertures discharge proportionally less water than those that are larger and of a similar figure, the water in the respective reservoirs being at the same height.

5. That of several apertures whose areas are equal, that which has the smallest circumference will discharge more water than the other, the water in the reservoirs being at the same altitude, and this because there is less friction. Hence, circular apertures are most advantageous, as they have less rubbing surface under the same areas. To this we can only add, that if instead of the orifice being pierced in a plate of tin or other thin plate, a cylindrical pipe or tube be inserted in the vessel whose length is from two to four times the diameter of the orifice, then a greater quantity of water will be discharged through it than through the simple aperture, in an equal portion of time, all other circumstances remaining the same; the quantity of the fluid discharged, in the two cases, being to each other as 133 to 100 nearly.

DISCHARGED, when applied to a ship, signifies when she is unladen, or her stores, ammunition, &c. taken out. When expressed of the officers or crew, it implies when they are disbanded from immediate service. When spoken of cannon, it means when it is fired off

DISCHARGER, or DISCHARGING *Rod*, in Electricity, is a rod used for the purpose of discharging a jar or battery of its contents, without injury or pain to the operator. Different forms have been given to this instrument, which are described by Cavallo and other authors on electricity.

DISCOUNT, or REBATE, is an allowance made on a bill or any other debt not yet become due, in consideration of present payment. Bankers, merchants, &c. allow for discount a sum equal to the interest of the bill for the time before it becomes due, which however is not just; for as the true value of the discount is equal to the difference between the debt and its present worth, it is equal only to the interest of that present worth, instead of the interest on the whole debt. And therefore the rule for finding the true discount is this: As the amount of £1 for the given rate and time is to the given sum or debt, so is the interest of £1 for the given rate and time to the discount of the debt. Thus if the interest or discount of money were five per cent. then the allowance on a bill of £100 would be found thus: As 21*s.* : £100 : : 20*s.* : £4. 15*s.* $2\frac{3}{4}$*d.* Such, however, is not the way in which business is done; for science has often as little to do with business as friendship. And the following is the popular rule, as given in all arithmetic books in vogue in our scientific schools. Thus Walkingham: As £100 present money will discharge a debt of £105 to be paid a year to come, rebate being made at 5 per cent.—*Rule.* As £100 with the interest for the time given, is to that interest, so is the sum given to the rebate required. Subtract the rebate from the given sum, and the remainder will be the present worth.—*Example.* What is the discount and present worth of £487. 12*s.* for six months, at 6 per cent. per annum?

```
          £.        £.     £.       £.   s.
6 m. ½)   6      As 103  :  3  : :  487  12
        ----         20               20
          3        ----             ----
        100        2060             9752
        ----                           3
        103                      ---------
        ----                206|0)2925|6(14l. 4s. rebate.
                                  206
  £.  s.                          ----
 487  12                          865
  14   4                          824
 ----  --                         ----
£473   8 present worth.           410—4s.
```

DISCRETE, or DISJUNCT *Proportion*, is that in which the ratio between two or more pairs of numbers is the same, and yet the proportion is not continued, so as that the ratio may be the same between the consequent of one pair and the antecedent of the next pair. Thus 3 : 6 : : 5 : 10 is a disjunct proportion; but 3 : 6 : : 12 : 24 is a continued proportion.

DISCRETE *Quantity*, is such as is not continued and joined together. Such, for instance, is any number; for its parts, being distinct units, cannot be united into one *continuum;* for in this there are no actual determinate parts, as there are in a number composed of several units.

DISCUTIENTS, in Surgery, are external remedies, which dissolve or disperse a stagnated or coagulated fluid.

DISGORGE, in the Manege, is used for discussing or dispersing an inflammation or swelling: thus, if a horse's legs are gorged or swelled, we say he must be walked out to *disgorge* them.

DISJUNCTIVE PROPOSITION, in Logic, is that where of several predicates we affirm one necessarily to belong to the subject, to the exclusion of all the rest, but leave that particular one undetermined.

DISLOCATION, the putting a bone out of joint by violence.

DISMANTLED, the state of a ship unrigged, and all her stores, guns, &c. taken out in readiness for being laid up in ordinary, or for any other purpose.

DISMASTED, the state of a ship deprived of her masts, whether by design or accident.

DISMOUNTED, the state of a cannon taken off a carriage, or when, by the enemy's shot, the carriage is so broken as that the gun is rendered unmanageable.

DISPARTING, in Gunnery, is setting a mark upon the muzzle ring, or thereabouts, of a piece of ordnance, so that a sight taken upon the top of the base ring, against the touch-hole, by the mark set on or near the muzzle, may be parallel to the axis of the concave cylinder.

DISPENSARY, a charitable institution, common in large towns of Britain. Dispensaries are supported by voluntary subscriptions, and each has one of more physicians, surgeons, and apothecaries, who attend, or ought to attend, at stated times, in order to prescribe for the poor, and, if necessary, to visit them at their own habitations. The poor are supplied with medicines gratis. Where these institutions are managed with care, they are of the utmost importance to society, it being unquestionably more for the comfort of the sick to be attended at their own houses, than to be taken from their families to an hospital.

DISPERSION, commonly signifies the scattering or dissipating the parts of any body; and hence, in Optics, it denotes the same as divergency.

Point of DISPERSION, in Dioptrics, the point from which the refracted rays begin to diverge when their refraction renders them divergent.

DISPERSION of *Light*, in Optics, denotes the enlargement of a pencil or beam of light, which is produced by its passage from one medium to another; and this enlargement arises from the nature of the medium.

DISSEISIN, in Law, is the wrongful putting out of one seised of the freehold, which may be effected either in corporeal inheritances or incorporeal. Disseisin of things corporeal, as of houses and lands, must be by entry and actual dispossession of the freehold. Disseisin of incorporeal hereditaments, cannot be an actual dispossession, for the subject is neither capable of actual bodily possession nor dispossession, but is only at the election and choice of the party injured, if, for the sake of more easily trying the right, he is pleased to suppose himself disseised. And so in corporeal hereditaments, a man may frequently suppose himself to be disseised, when he is not in fact, for the sake of entitling himself to the more easy remedy of an assise of novel disseisin, instead of the process of a writ of entry.

DISSENTERS, in Church History, a numerous body of people in this country, who made their first appearance in Queen Elizabeth's time, when, on account of the extraordinary purity which they proposed in religious worship and conduct, they were reproached with the name of Puritans. They increased in numbers by the act of uniformity, which took place on Bartholomew's day 682, in the reign of Charles II. By this act, 2000 ministers of the establishment, refusing to conform to certain conditions, were obliged to quit their livings, and hence arose the name of Non-conformists. The descendants of these are known by the name of Protestant Dissenters: and may be considered, in general, as divided into the denominations of Presbyterians, Independents, and Baptists.

DISSIPATION, in Physics, an insensible loss or consumption of the minute parts of a body, or that agency whereby they fly off and are lost.

Circle of DISSIPATION, in Optics, denotes the circular space upon the retina, which is taken up by one of the extreme pencils of rays issuing from any object.

Radius of DISSIPATION, is the radius of the circle of dissipation.

DISSOLVENT, any thing which dissolves.

DISSOLUTION, the separation of a body into its most minute parts.

DISTANCE, in Astronomy, the space between the sun and any of the planets, &c. as shewn in the following table of the real and proportional distances of the several planets.

	Proportional Mean Dist.	Real Mean Dist.	
Mercury,	·3870981	36	Millions of Miles from the Sun.
Venus,	·7233323	68	
Earth,	1·0000000	93	
Mars,	1·5236935	142	
Vesta,	2·2373000	221	
Juno,	2·6671630	248	
Ceres,	2·7674060	257	
Pallas,	2·7675920	257	
Jupiter,	5·2027911	485	
Saturn	9·5387705	890	
Uranus,	19·1833050	1800	

DISTANCE of the *Fixed Stars* from the Earth or Sun, has never yet been determined; we only know it is so great, that the whole diameter of the earth's orbit, which is near two hundred million miles, is but as a point compared with their distance, and therefore forms no sensible measure whereby it may be estimated.

DISTANCE of the *Sun* from the Moon's Node or Apogee, is an arch of the ecliptic intercepted between the sun's true place and the moon's node or apogee.

Accessible DISTANCES, are such as may be measured by the application of any lineal measure. *Inaccessible* DISTANCES, are those which cannot be measured by the application of any lineal measure, but by means of angles and trigonometrical rules and formulæ. *See* ACCESSIBLE.

The distance of objects may also be ascertained by means of sound; for as this has been found, by experiment, to travel at the rate of about 1142 feet per second, if the time which elapses between the firing of a gun and the report of the same be duly observed, the distance in feet will be found by multiplying the number of seconds by 1142; and in this way we may estimate the distance of a thunder cloud, by the number of seconds being observed that elapses between the flash of lightning, and the clap of thunder by which it is succeeded. *See* ACOUSTICS.

Apparent DISTANCE, in Optics, is that distance at which we judge an object to be placed when seen afar off, and which is usually very different from the true distance, because we are apt to think that all very remote objects whose parts cannot well be distinguished, and which have no other object in view near them, are at the same distance from us, though perhaps one of them is thousands of miles nearer than the other, as is the case with the sun, moon, and planets.

The most universal, and frequently the most sure means of judging of the distance of objects, is the angle made by the optic axis. For our two eyes are like two different stations, by the assistance of which distances are taken; and this is the reason why those persons who are blind of one eye so frequently miss their mark in pouring liquor in a glass, snuffing a candle, and such other actions as require that the distance be exactly distinguished. To convince ourselves of the usefulness of this method of judging of the distance of objects, we have only to suspend a ring in a thread, so that its side may be towards us, and the hole in it to the right and left hand; and taking a small rod, crooked at the end, retire from the ring two or three paces, and having with one hand covered one of our eyes, to endeavour with the other to pass the crooked end of the rod through the ring. This appears very easy, and yet upon trial, perhaps once in 100 times we shall not succeed, especially if we move the rod a little quickly. By persons recollecting the time when they began to be subject to the mistakes above mentioned, they may tell when it was that they lost the use of one of their eyes, which many persons are long ignorant of, and which may be a circumstance of some consequence to a surgeon. The use of this second method of judging of distances, De Chales limits to 120 feet, beyond which, he says, we are not sensible of any difference in the angle of the optic axis.

A third method of judging of the distance of objects consists in their apparent magnitudes. From this change in the magnitude of the image upon the retina, we easily judge of the distance of objects, as often as we are otherwise acquainted with the magnitude of the objects themselves; but as often as we are ignorant of the real magnitude of bodies, we can never, from their apparent magnitude, form any judgment of their distance.

From this we may see why we are so frequently deceived in our estimates of distance, by any extraordinary magnitudes of objects seen at the end of it, as in travelling towards a large city, or a castle, or a cathedral church, or a mountain larger than ordinary, we fancy them to be nearer than we find them to be. This also is the reason why animals, and all small objects seen in valleys contiguous to large mountains, appear exceedingly small. For we think the mountain nearer to us than if it were smaller, and we should be surprised at the smallness of the neighbouring animals, if we thought them farther off. For the same reason we think them exceedingly small when they are placed on the top of a mountain, or a large building, which appears nearer to us than it really is, on account of its extraordinary size.

Our imagining objects, when seen from a high building, to be smaller than they are, and smaller than we fancy them to be when we view them at the same distance on level ground, is because we have no distinct idea of distance in that direction, and therefore judge of the things by their pictures upon the eye only, but custom will enable us to judge rightly even in this case. Let a boy who has never been upon a high building, go to the top of the Monument, and look down into the street; the objects seen there, as men and horses, will appear so small as greatly to surprise him. But ten or twenty years after, if in the mean time he has used himself now and then to look down from that and other great heights, he will no longer find the same objects to appear so small. The finest sight of this nature is from a balloon. *See* AEROSTATION. We have had a very fine sight ourselves of this nature, in surveying from the lofty spire of St. Denis, in France, a large army in the plain between that cathedral and Paris. And if a person were to view the same objects from such heights as frequently as he sees them upon the same level with himself in the streets, they would appear to him just of the same magnitude from the top of the Monument as they do from a window one story high. For this reason it is, that statues placed upon very high buildings ought to be made of a larger size than those which are seen at a nearer distance, because all persons, except architects, are apt to imagine the height of such buildings to be much less than it really is.

The fourth method by which we judge of the distance of objects, is the force with which their colour strikes upon our eyes. For if we be assured that two objects are of a similar and like colour, and that one appears more bright and lively than the other, we judge that the brighter object is the nearer of the two.

The fifth method consists in the different appearance of the small parts of objects. When these parts appear distinct, we judge that the object is near; but when they appear confused, or when they do not appear at all, we judge that it is at a greater distance. For the image of any object, or part of an object, diminishes as its distance from our eye increases.

The sixth and last method by which we judge of the distance of objects is, that the eye does not represent to our mind one object alone, but at the same time all those that are placed betwixt us and the principal object, whose distance we are considering; and the more this distance is divided into separate and distinct parts, the greater it appears to be. For this reason, distances upon uneven surfaces appear less than upon a plane; for the inequalities of the surface, such as hills, and holes, and rivers, that lie low and out of sight, either do not appear, or hinder the parts that lie behind them from appearing; and so the whole apparent distance is diminished by the parts that do not appear in it. This is the reason that the banks of a river appear contiguous to a distant eye, when the river is low and not seen. How much narrower does a river that is subject to the influence of the tide appear at low water, than when its bosom is proudly swelled at high water mark? and yet perhaps the actual breadth at both times does not vary 20 feet.

Distance, in Navigation, is the number of miles or leagues that a ship has sailed from one point to another.

Line of Distance, in Perspective, is a right line drawn from the eye to the principal point of the plane. *Point* of Distance, in Perspective, is that point in the horizontal line which is at the same distance from the principal point as the eye is from the same.

DISTANCE of the Eye, in Perspective, is a line drawn from the eye to the principal point.

DISTEMPER, in Painting, a term used for the working up of colours with something besides water or oil. If the colours are prepared with water, that kind of painting is called limning; and if with oil, it is called painting in oil, and simply painting. If the colours are mixed with any glutinous or unctuous matter instead of oil, it is said to be done in distemper. In this manner the cartoons at Windsor are painted.

DISTICH, a couplet of verses making a complete sense. Thus hexameter and pentameter verses are disposed in distichs.

DISTILLATION. Under the article Chemistry, we explained what distilling means, and how it is performed; the subject of the present article is confined to the making of ardent spirits, or alcohol,—the distillation of gases belonging to another part of our work.

Previously to the operation of distilling, those of brewing and fermentation are necessary; the liquid must be brought into the state of wine, or beer, (which is the wine of grain.) Methods have been suggested, and we believe carried into practice, for reducing the brewing and fermentation to a single operation, by which, it is said, the spirit is much improved in quality, as well as augmented in quantity. The practice, we are informed, is as follows:—

To one hundred pounds of malt, reduced to fine meal, are added thirty pounds of wheat meal; twenty gallons of water are then added by degrees, mixing the whole mass thoroughly; fifty gallons more of water, made boiling hot, are then poured upon the mass, and the whole well stirred together. It is then allowed to stand for two hours, afterwards stirred again, and when grown cold, a pound or more of solid yeast is added, and then allowed to stand loosely covered in rather a warm place to ferment.

In London, and its neighbourhood, we understand the process of forming the wash for distillation is the same as in brewing for beer, with the exception of the addition of the hops, and that instead of boiling the wort, they pump it into coolers, and afterwards draw it into backs, to be then fermented with yeast. During the fermentation, particular attention must be paid to the temperature of the liquid: if it exceeds 77° Fahrenheit, the fermentation will be too rapid; if below 60°, the fermentation will cease. The mean between these is considered the most favourable, and the fermentation must be continued until the liquor grows fine and pungent to the taste, but not so long as to permit the acetous fermentation to commence. In this state the wash is put into the still, of which it should occupy about three-fourths, and distilled with a gentle fire, as low as any spirit comes over, which is generally until about half the wash is consumed.

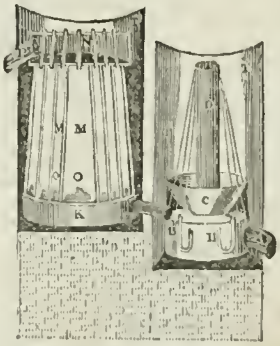
The form of the common still is too well known to need any particular description; it generally consists of a large boiler made of copper, and fixed in masonry over a fireplace; the boiler has a head, or capital as it is called, which is of a globular form, to which is soldered a neck, which forming a complete arch, curves downward, and fits into what is called the worm. The worm is a long tube, made generally of pewter, of a gradually decreasing diameter, and is curled round into a spiral form; it is enclosed in a tub, which is kept filled with cold water during distillation.

The Dutch method of making Geneva is said to be as follows:—"One hundred weight of malt from barley, and two hundred weight of rye meal, are mashed, with four hundred and sixty gallons of water, heated to 162° Fahrenheit. When the infusion has been continued a sufficient time, cold water is added until the wort is equivalent to about forty-five pounds of saccharine matter per barrel; it is then drawn off into a back of five hundred gallons' capacity, at the temperature of 80°, with half a gallon of yeast. The fermentation immediately commences, and is generally finished in about two days, when proper attention is paid to the temperature of the place. The wash is then put into the still, reduced to about fifteen pounds of saccharine matter per barrel, along with the grains, and receives three distillations, a few juniper berries, and a small quantity of hops, being introduced to communicate the flavour required."

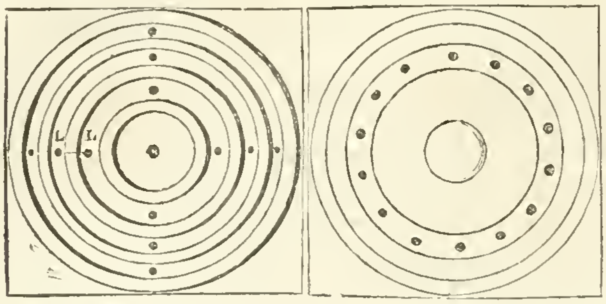
The spirits of the first distillation is usually called *low wines*; the re-distillation of the *low wines*, or *doubling*, produces at first a fiery spirit, milky and crude, (which is returned into the low wines); after this the spirit flows perfectly clear and bright; nevertheless, tainted a little with empyreuma, to get rid of which it generally undergoes another distillation called rectification, at which time flavouring ingredients are added, to imitate the foreign spirits, such as rum, brandy, hollands, gin, &c. and likewise to form the compound spirits, called caraway, peppermint, cinnamon, cloves, aniseed, &c.

The flavour of malt spirit is said to be much improved, by putting four ounces of finely-powdered charcoal, and four ounces of ground rice, into a quart of spirits, and letting it stand for a fortnight, frequently stirring it; upon being then strained, it will be found to resemble very closely the flavour of brandy. It has been frequently proved, that the muriate of soda (or common salt) thrown into the still in the proportion of about half an ounce to every gallon, will materially improve the taste and strength of the spirit; the viscid matter being fixed by the salt, allows the volatile parts to ascend in greater purity. Some time since, a distiller at Copenhagen published an account of his having several times distilled brandy and gin from wheat steeped in salt water, by which he uniformly obtained nearly one-fourteenth more of spirit, than when he distilled from an equal quantity of wheat, which had not undergone that process.

It is said to be the practice of the distillers in Scotland, &c. to use one part of malted grain, with from four to nine parts of raw grain; rye is said to produce more spirit than wheat, and wheat more spirit than barley.



Winter's *Distilling Apparatus*, exhibited in the annexed figures, is constructed on the principle of condensing the aqueous portion of the mixed liquor previously to its passing into the still. A, in this sectional view, is a tube by which the vapours enter from the still into B the receiver. C is a conical plate. D the chief vapour tube, which being closed at the top, the vapours descend by the small tubes G, into the chamber F. The apparatus is isolated in water of 170° temperature, contained in the tub or bath T, and as the vapours contained in the tubes are by this arrangement separated into small portions, a rapid condensation takes place. A number of circular tubes, as at H, are fixed in the plate which covers the receiver B, with their upper ends a little above the surface. These carry off the condensed liquor into the receiver B. The vapour, now improved in its spirit, is collected in the chamber F, and passes by the tube I into the second receiver K. The top plate of this second receiver K, as well as the bottom plate of the third receiver N, have numerous apertures of concentric circles as at L L, in the following figure, into each of which are fitted two copper cylinders, one within the other, and only about a quarter of an inch apart. And as there are four such apertures, there are consequently eight pairs of apertures.

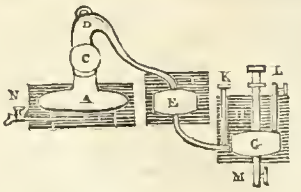


Into each of these annular apertures L, L, are fixed two copper cylinders, one within the other, and only about a quarter of an inch apart; and as there are four such apertures, there are consequently eight cylinders or four pairs in the apparatus, which are exhibited in section in the first engraving at M, M. O, O are tubes which pass through the receiver K, to convey water between the cylinders; similar tubes are passed through the receiver N, by which means the water is diffused over every part of the extended surface of the apparatus, effecting thereby almost as rapid a condensation of the aqueous portion of the vapour, as if the water were in actual contact with it. The vapours passing from the lower receiver K, ascend, as before mentioned, through the narrow spaces between the cylinders into the upper receiver N, in a high state of purity and strength; from this last hold it proceeds into the worm by the tube P, where it is instantly condensed by the refrigerating effect of the cold water with which this part of a distillatory apparatus is always surrounded.

It is, perhaps, not unnecessary to repeat, that the water contained in the second bath T, shewn in section, is heated to 140° (or less, as the spirit may be required,) that being a degree of temperature to which the vapour of water, as well as those from the empyreumatic oils, cannot exist. The spirit is thus separated effectually, and without any difficulty, from the least taint of empyreuma, with which British spirits are in general more or less contaminated.

It will be observed, that this second receiver is of a peculiar construction, and being kept at a temperature of 140°, the whole of the weaker vapour is therein reduced into a liquid state, while the strong spirituous vapour, ascending alone through certain very narrow spaces, contained between the circuitous cylinders, into the deeper part of the apparatus, is thence collected into a third receiver previously to its passing into the worm. The worm is surrounded as usual with cold water, whose powerful refrigerating effects upon the strong spirituous vapour with which it is charged, causes it rapidly to pass into a fluid state. In this still the spirit might be rectified or flavoured, by allowing the vapours to pass through the necessary ingredients as they pass on to the worm. We need not speculate on the advantages of this apparatus, which is manufactured by Messrs. Pontifex, Sons, and Co. London.

Distillation *by a low heat, in close vessels.* Those who are acquainted with the common method of distilling, know that a very unpleasant flavour accompanies all distilled products, occasioned by the matter in the still being overheated, or burned. The late James Watt ascertained, that liquids boiled at a very low temperature in vacuo, or by emptying the apparatus of atmospheric air; and Mr. Tretton, of Whitechapel, London, ingeniously applied this fact to distillation, and constructed the annexed apparatus, wherein the body of the still is seen as immersed in a water bath, which renders it impossible to overheat or burn the liquid, or communicate the disagreeable empyreumatic flavour to spirit, as is done by the common still. A is the body of the still; B is a water bath, into which the body of the still is immersed; C is the head, or capital; D is the neck of the same, which, curving downwards, is connected with a pipe that enters the condensing vessel E; F is a refrigeratory, or close vessel, containing cold water, for converting into liquid the spirituous vapours, which having been raised in the still, are contained in the vessel E. From the bottom of the vessel E a pipe issues for conveying the liquid, and the vapour not yet condensed, into vessel G, which being surrounded with cold water contained in the vessel H, acts also as a refrigeratory, and reduces the whole of the remaining vapour into a liquid state. I is an air-pump for effecting a vacuum in the vessels A E G. K is a stop-cock for cutting off the communication between the vessels E and G, when the contents of G are drawn off by the cock M, by which means a vacuum is preserved, during that operation in the vessel E and the still A; L is an air-cock, to admit air into vessel G, to allow the contents to run out at M; N is a discharge-cock to the still A.



The pressure of the atmosphere being removed from the surface of the liquid by the air-pump, the distillation is effected at a temperature of 132° in place of 212°, and of course from the regular application of so low a degree of heat, an agreeable flavour is secured to the distilled product. Moreover, from the distillation being confined throughout the operation to close vessels, the common loss by evaporation at the end of the worm is avoided, and an increase of product is obtained.

DISTINCT Base, in Optics, is the same with what is otherwise called the focus.

DISTINCTION, in Logic, is an assemblage of two or more words, whereby disparate things, or their conceptions, are denoted. There are three kinds of distinctions, taken from the three different modes of existence, real, modal, and rational. The first is that between two substances, or the modes of two substances. The second is that between several things, one whereof may exist without the other, but not vice versâ. The third is that between several things which are really one and the same, and whereof one cannot exist without the other; nor, vice versâ, the other without this; such is that between a thing and its essence, between the essences and properties, &c.

DISTRESS, in Law, is the taking of a personal chattel, out of the possession of the wrong doer, into the custody of the person who is injured, to procure a satisfaction for the wrong committed. It is of two kinds; cattle for trespassing and doing damage, or for the non-payment of rent or other duties. But the most usual injury for which a distress may be taken, is that of non-payment of rent.

DISTRINGAS, in Law, a writ commanding the sheriff, or other officer, that he distrain a person for debt to the king, &c. or for his appearance at a certain day. There is a great diversity of this writ.

DITTON, Humphrey, a mathematician of the seventeenth century, born at Salisbury, May 29, 1675, was author of several tracts which were published in the Philosophical Transactions.

DIVERGENT, tending to various parts from one point; thus we say, diverging lines, rays, &c. meaning those lines or rays which issuing from one common point, go off from that point in various directions.

DIVERGING Series, in Analysis, are those series, the terms of which increase more and more, the farther they are continued.

DIVERSITY, in Painting, consists in giving every part or figure in a piece its proper air and attitude.

DIVIDEND of Stocks, is a share or proportion of the interest of stocks erected on public funds, as the South Sea, &c. divided among, and paid to, the proprietors half yearly.

DIVIDEND, in Arithmetic, is that number which is to be divided by some other number called the divisor.

DIVING, the art of descending under water to considerable depths, and remaining there for some time in order to recover things which have been sunk, as also for the purpose of bringing up corals, pearls, sponge, &c.

Diving *Bell*, an apparatus used for the purpose of diving. *See* Bell.

There have been various engines contrived to render the business of diving safe and easy: the great point, is to furnish the diver with fresh air, without which he must either make but a short stay or perish. Those who dive for sponges in the Mediterranean, carry down sponges dipped in oil in their mouths. But considering the small quantity of air that can be contained in the pores of a sponge, and how much that little will be contracted by the pressure of the incumbent water, such a supply cannot subsist a diver long, since a gallon of air is not fit for respiration above a minute. Dr. Halley assures us, a naked diver cannot subsist above two minutes under water with or without a sponge; besides, if the depth be considerable, the pressure of the water makes the eyes blood-shot, and frequently occasions a spitting of blood.

An experiment was lately tried at Rouen upon a new invented diving machine, called *batteau-poisson*, or fishboat. This boat sunk of itself seven or eight minutes, and then rose of itself. The longest time it remained under water was eight minutes. The descent into the inside of this machine was by an opening made in the form of a tunnel, which was about a demimetre above the surface of the water. When those who conducted the experiment wished to descend altogether in the river and disappear, they let down this opening, sunk entirely under the water, and lost all communication with the external air. The inventor of this ingenious machine was Fulton. Three of his assistants went into the boat, and remained during the experiment. The prefect and a vast concourse of spectators were present.

Diving *Bladder*, is a term used by Borelli, for a machine which he contrived for diving under the water to great depths, with great facility, and which is preferred to the common diving bell. The vesica, or bladder, as it is usually called, is to be of brass or copper, and about two feet in diameter. This is to contain the diver's head, and is to be fixed to a goat-skin habit, exactly fitted to the shape of the body of the person. Within this vesica there are pipes, by means of which a circulation of air is contrived; and the person carries an air-pump by his side, by means of which he may make himself heavier or lighter, as the fishes do, by contracting or dilating their air bladder.

DIVISIBILITY, an essential property of bodies. Every substance with which we are acquainted is capable of being separated into parts, and each of these again repeatedly subdivided. Nor has any limit ever been assigned to this process of continual subdivision, though it seems probable that, at some term, however distant, the resulting particles may lapse into simple *atoms*, incapable of any farther resolution.

The actual subdivision of bodies has, in many cases, been carried to a prodigious extent. A slip of ivory, of an inch in length, is frequently divided into an hundred equal parts, which are distinctly visible. But, by the application of a very fine screw, five thousand equidistant lines, in the space of a quarter of an inch, can be traced on a surface of steel or glass with the fine point of a diamond, producing delicate iridescent colours. Common writing paper has a thickness of about the 500th part of an inch; but the pellicle separated from ox-gut, and then doubled to form gold-beaters' skin, is six times thinner. A single pound of cotton has been spun into a thread 76 miles in length; and the same quantity of wool has been extended into a thread of 95 miles; the diameters of those threads being hence only the 350th and 400th parts of an inch.

But the ductility of some metals far exceeds that of any other substance. The gold-beaters begin with a riband an inch broad and 150 inches long, which has been reduced, by passing through rollers, to about the 800th part of an inch in thickness. This riband is cut into squares, which are disposed between leaves of vellum, and beat by a heavy hammer, till they acquire a breadth of more than three inches, and are therefore extended ten times. These are again quartered, and placed between the folds of gold-beaters' skin, and stretched out, by the operation of a lighter hammer, to the breadth of five inches. The same process is repeated, sometimes more than once, by a succession of lighter hammers; so that 376 grains of gold are thus finally extended into 2000 leaves, of 3.3 inches square, making in all 80 books, containing each 25 leaves. The metal is consequently reduced to the thinness of the 282,000th part of an inch, and every leaf weighs rather less than the fifth part of a grain.

Silver is likewise capable of being laminated, but will scarcely bear an extension above half that of gold, or the 150,000 part of an inch thick. Copper and tin have still inferior degrees of ductility, and cannot perhaps be beat thinner than the 20,000th part of an inch. These form what are called Dutch Leaf.

In the gilding of buttons, five grains of gold, which is applied as an amalgam with mercury, is allowed to each gross; so that the coating left must amount to the 110,000th part of an inch in thickness. If a piece of ivory or white satin be immersed in a nitro-muriate solution of gold, and then plunged into a jar of hydrogen gas, it will become covered with a surface of gold hardly exceeding in thickness the ten millionth part of an inch.

The gilt wire used in embroidery is formed by extending gold over a surface of silver. A silver rod, about two feet long and an inch and half in diameter, and therefore weighing nearly twenty pounds, is richly coated with about 800 grains of pure gold. In this country the lowest proportion allowed is 100 grains of gold to a pound of silver. This gilt rod is then drawn through a series of diminishing holes, till it has stretched to the vast length of 240 miles, when the gold has consequently become attenuated 800 times, each grain covering a surface of 9600 square inches. This wire being now flatted, the golden film suffers a farther extension, and has its thickness reduced to the four or five millionth part of an inch.

It has been asserted, that wires of pure gold can be drawn of only the 4000th part of an inch in diameter. But Dr. W. H. Wollaston, by an ingenious procedure, has lately advanced much farther. Taking a short cylinder of silver, about the third part of an inch in diameter, he drilled a fine hole through its axis, and inserted a wire of platinum only the 100th part of an inch thick. This silver mould was now drawn through the successive holes of a steel plate, till its diameter was brought to near the 1500th part of an inch, and consequently the internal wire, being diminished in the same proportion, was reduced to between the 4 and 5000th part of an inch. The compound wire was then dipped in warm nitric acid, which dissolved the silver, and left its core, or the wire of platinum. By passing the incrusted platinum through a greater number of holes, wires still finer were obtained, some of them only the 30,000th part of an inch in diameter. The tenacity of the metal, before reaching that limit, was even considerable; a platinum wire of the 18,000th part of an inch in diameter supporting the weight of one grain and a third.

Such excessive fineness is hardly surpassed by the filamentous productions of nature. Human hair varies in thickness, from the 250th to the 600th part of an inch. The fibre of the coarsest wool is about the 500th part of an inch in diameter, and that of the finest only the 1500th part. The silk line, as spun by the worm, is about the 5000th part of an inch thick; but a spider's line is perhaps six times finer, or only the 30,000th part of an inch in diameter, insomuch, that a single pound of this attenuated substance might be sufficient to encompass our globe.

The red globules of the human blood have an irregular roundish shape, from the 2500th to the 3300th of an inch in diameter, with a dark central spot.

The trituration and levigation of powders, and the perennial abrasion and waste of the surface of solid bodies, occasion a disintegration of particles, almost exceeding the powers of computation. Emery, after it has been ground, is thrown into a vat filled with water, and the fineness of the powder is distinguished by the time of its subsidence. In very dry situations, the dust lodged near the corners and crevices of ancient buildings is, by the continual agitation of the air, made to give a glossy polish to the interior side of the pillars and the less prominent parts of those venerable remains. So fine is the sand on the adust plains of Arabia, that it is carried sometimes 300 miles over the Mediterranean, by the sweeping and violent Sirocco. Along the shores of that sea, the rocks are peopled by the *pholas*, a testaceous and edible worm, which, though very soft, yet, by unwearied perseverance, works a cylindrical hole into the heart of the hardest stone. The marble steps of the great churches in Italy are worn by the incessant crawling of abject devotees; nay, the hands and feet of bronze statues are, in the lapse of ages, wasted away by the ardent kisses of innumerable pilgrims that resort to those shrines. What an evanescent pellicle of the metal must be abraded at each successive contact!

The solutions of certain saline bodies, and of other coloured substances, exhibit a prodigious subdivision and dissemination of matter. A single grain of the sulphate of copper, or blue vitriol, will communicate a fine azure tint to five gallons of water. In this case the copper must be attenuated at least ten million times; yet each drop of the liquid may contain as many coloured particles, distinguishable by our unassisted vision. A still minuter portion of cochineal, dissolved in deliqueate potash, will strike a bright purple colour through an equal mass of water.

Odours are capable of a much wider diffusion. A single grain of musk has been known to perfume a large room for the space of twenty years. Consider how often, during that time, the air of the apartment must have been renewed, and have become charged with fresh odour! At the lowest computation, the musk had been subdivided into 320 quadrillions of particles, each of them capable of affecting the olfactory organs. The vast diffusion of odorous effluvia may be conceived from the fact, that a lump of *assafœtida*, exposed to the open air, lost only a grain in seven weeks. Yet, since dogs hunt by the scent alone, the effluvia emitted from the several species of animals, and from different individuals of the same race, must be essentially distinct.

The vapour of pestilence conveys its poison in a still more subtile and attenuated form. The seeds of contagion are known to lurk for years in various absorbent substances, which, on exposure to the air, scatter death and consternation.

But the diffusion of the particles of light defies all powers of calculation. A small taper will, in a twinkling, illuminate the atmosphere to the distance of four miles; yet the luminous particles which fill that wide concavity cannot amount to the 5000th part of a grain, which may be the whole consumption of the wax in light, in smoke, and ashes.

Animated matter likewise exhibits, in many instances, a wonderful subdivision. Between the Tropics, the small marine polypi, by the immensity of their combined numbers, speedily raise up clusters of coral reefs, so dangerous at present to the navigation of those seas, but which are destined, at no very remote period, to form groups of inhabited and cultivated islands. The milt of a codfish, when it begins to putrefy, has been computed to contain a billion of perfect insects; so that thousands of these living creatures could be lifted on the point of a needle. But the infusory animalcules display, in their structure and functions, the most transcendent attenuation of matter. The *vibrio undula*, found in duck-weed, is computed to be ten thousand million times smaller than a hemp seed. The *vibrio lineola* occurs in vegetable infusions, every drop containing myriads of those oblong points. The *monas gelatinosa*, discovered in ditch-water, appears in the field of a microscope a mere atom endued with life, millions of them playing like the sunbeams in a single drop of liquid.

Insects have been discovered so small as not to exceed the 10,000 part of an inch, so that 1,000,000,000,000 of them might be contained within the space of one cubic inch, yet each animalcule must consist of parts connected with each other, with vessels, with fluids, and with organs necessary for its motions, for its increase, for its propagation, &c. How inconceivably small must those organs be; and yet they are unquestionably composed of other parts still smaller, and still farther removed from the perception of our senses.

DIVISION, in the Navy, a select number of ships in a fleet or squadron of men-of-war, distinguished by a particular flag, pendant, or vane, and sometimes commanded by a general officer. A squadron is commonly ranged into three divisions, the commanding officer of which is always stationed in the centre. In a large fleet the admiral divides it into three squadrons, each of which is commanded by an admiral, and is again divided into three divisions; each squadron has its proper colours, according to the rank of the admiral who commands it; and each division its proper mast. The private ships carry pendants of the same colour with their respective squadrons at the masts of their particular divisions, so that the ships in the last division of the blue squadron carry a blue pendant at their mizzen top-gallant-mast-head. These distinctions of divisions are not, however, constantly practised. The general officers or commanders of divisions place themselves in the centre of the divisions, the three commanding admirals excepted, who, in a sailing position, lead their respective squadrons.—In the Army, a body of troops composed of several brigades, and commanded by a general officer.

DIVISION, in Natural Philosophy, is the taking a thing to pieces, in order to have a more complete conception of the whole: this is frequently necessary in examining very complex beings, the several parts of which cannot be surveyed at one view.

DIVISION, is one of the principal rules in Arithmetic and Algebra: it consists in finding how often a less number is contained in a greater. The number to be divided is called the *dividend*, the number by which the division is made is the *divisor*; the number of times that this is contained in the former is called the *quotient*, and if any thing remains after the operation is finished, it is called the *remainder*. Division is either simple or compound.

Simple DIVISION, is when both the divisor and dividend are integral numbers.

Rule.—Draw a small curve-line on the right and left of the dividend, and write the divisor on the left; then find how many times the divisor is contained in as many of the left-hand figures of the dividend as are just necessary, and place that number on the right. Multiply the divisor by this number, and place the product under the figure of the dividend above mentioned. Subtract this product from that part of the dividend under which it stands, and bring down the next figure of the dividend, or more if necessary, to the right of the remainder. Divide this number, so increased, as before, and so on till the whole is finished. *Note* 1. When it is necessary to bring down more than one figure to the remainder, a cipher must be placed in the quotient for every figure thus brought down. 2. If the divisor do not exceed 12, the quotient may be written down as it arises, immediately under the dividend.—*Proof* of DIVISION. Multiply the divisor and quotient together, and add to this product the remainder, which ought to be equal to the dividend, if the work be right.

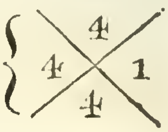
Example.

```
5)674346(1         7)643287(1        346 ) 7486716 ( 21637
  ------             --------               692        346
                                            ---      ------
   134869 quotients  91898                  566     129822
        5                7                  346      86548
   ------             -----                 ---     64911
   674346  proof     643287                 2207       314
   ------            ------                 2076   -------
                                           -----   7486716 proof.
                                             1311  -------
                                             1038
                                            -----
                                             2736
                                             2422
                                             ----
                                              314
```

Sometimes, for the sake of abridging the operation, the successive products are omitted, and the subtraction is made figure for figure as the work is carried on; by this method, the foregoing example would stand as follows:—Division may also be proved by the cross, the same as multiplication, by casting out the nines from the divisor and quotient; and again out of the product of their remainders; and this last remainder ought to be the same as that arising from the dividend, after the remainder, arising in the operation, is subtracted from it; thus,

```
346)7486716(21637
     566
     2207
      1311
       2736
        314
```

proof



This is generally called the *Italian method of division.*

Compound DIVISION, is when the dividend is a compound quantity.—*Rule.* Divide the highest denomination of the dividend by the divisor, as in the former rule. Reduce the remainder, if any, to the next inferior denomination, and divide as before; reduce this remainder again, and divide as before; and so on till the whole is finished. *Note.* If the divisor exceed 12, and be a composite number, divide by its factors successively, instead of the whole number at once.

$$\begin{array}{lrrrlrrr} & £. & s. & d. & & £. & s. & d. \\ \textit{Example.}\ 3) & 4 & 13 & 9(& & 7)\,9 & 13 & 11(\\ \hline & 1 & 11 & 3 & \text{quotient} & 1 & 7 & 9\tfrac{5}{7} \\ & & & 3 & & & & 7 \\ \hline & 4 & 13 & 9 & \text{proof} & 9 & 13 & 11 \\ \hline \end{array}$$

3. Divide £214. 14*s.* 10*d.* by 24.

$$24 = 4 \times 6 \qquad \begin{array}{rrrr} & £. & s. & d. \\ 4) & 214 & 14 & 10(\\ \hline 6) & 53 & 13 & 8\tfrac{1}{2}(\\ \hline & 8 & 18 & 11\tfrac{1}{4}\ \tfrac{1}{6} \end{array}$$

DIVISION of *Fractions*, is performed by the following rule. Reduce all mixed numbers to improper fractions, then invest the terms of the divisor, and multiply the numerators and the denominators together as in multiplication, observing that such factors as are common in the numerators and denominators may be cancelled.

Examples.

1. $\frac{7}{9} \div \frac{3}{4} = \frac{7}{9} \times \frac{4}{3} = \frac{28}{27}$
2. $\frac{3}{11} \div \frac{4}{9} = \frac{3}{11} \times \frac{9}{4} = \frac{27}{44}$
3. $1\frac{6}{8} \div \frac{3}{4} = \frac{14}{8} \times \frac{4}{3} = \frac{7}{3}$
4. $2\frac{1}{3} \div 4\frac{1}{2} = \frac{7}{3} \times \frac{2}{9} = \frac{14}{27}$

DIVISION of *Decimals*, is performed the same as in the simple rule of division, observing only to point off in the quotient as many decimal places, as those in the dividend exceed those in the divisor; and if there be not so many, the defect must be supplied by prefixing ciphers. Another way to know the place for the decimal point is this: the first figure of the quotient must be made to occupy the same place either in integers or decimals, as does that figure of the dividend that stands over the unit's place of the first product. *Note.* The division may be carried on to any extent required by annexing ciphers to the remainders after all the given figures have been used.

$$\begin{array}{ll} \textit{Example.} & 486{\cdot}4)748{\cdot}6840(1{\cdot}615\ \text{quotient.} \\ & \quad 298\,28 \\ & \quad\ 7\,444 \\ & \quad\ 2\,5800 \\ & \quad\ \ 1480 \end{array}$$

DIVISION of *Circulating Decimals*, is performed by converting the repetends into their equivalent fractions, and then proceeding as in division of fractions.

DIVISION, in Algebra, is the method of finding the quotient arising from the division of one intermediate quantity by another, which may be considered under two cases.

Case 1. When the divisor and dividend are both simple quantities. *Rule.* Divide the co-efficients, as in arithmetic, and to the quotient annex the result arising from the division of the indeterminate quantities. *Note.* When the divisor and dividend have like signs, the sign of the quotient is plus +; and when they are unlike, the sign of the quotient is minus —, as in multiplication.

$$\begin{array}{llll} \textit{Example.} & 6ab\,)\,24a^2b^2 & 7x^2)\,35x^3y^3 & 6x^2\sqrt{y})\,72x^3y \\ \hline & \quad 4a\ b & \quad 5x\ y^3 & \quad 12x\sqrt{y} \\ \hline & -4ab^2)\,32abc^2 & -4xy)-16x^2y^3 & 4a^2b)-24a^3b^3c^3 \\ \hline & \quad -8c & \quad +\ 4x\ y^2 & \quad -\ 6ab^2c^3 \\ \hline \end{array}$$

Case 2. When the dividend is a compound quantity, and the divisor either simple or compound. *Rule.* Set the divisor on the left of the dividend, and proceed in the operation the same as in division of numbers, observing still the same rule as above with regard to the signs.

Examples.

$$\begin{array}{rl} a-b\,) & a^2-2ab+b^2\,(a-b \\ & a^2-\ ab \\ \hline & -\ ab+b^2 \\ & -\ ab+b^2 \\ \hline \end{array} \qquad \begin{array}{rl} x+y\,) & x^3+y^3\ (x^2-xy+y^2 \\ & x^3+x^2y \\ \hline & -x^2y+y^3 \\ & -x^2y-xy^2 \\ \hline & +xy^2+y^3 \\ & +xy^2+y^3 \\ \hline \end{array}$$

DIVISION of *Algebraic Fractions*, is performed the same way as in the case of simple fractions, *viz.* reduce all mixed expressions to improper fractions, then invert the terms of the divisor, and multiply the numerators and denominators as in the rule above quoted, observing to cancel all factors that are common to the numerators and denominators.

Examples.

1. $\frac{5a}{4b} \div \frac{3a^2}{5c^2} = \frac{5a}{4b} \times \frac{5c^2}{3a^2} = \frac{25c^2}{12ab}$
2. $\frac{3xy}{5x^2z} \div \frac{9wz}{7x^2y^3} = \frac{3xy}{5x^2z} \times \frac{7x^3y^3}{9wz} = \frac{7x^2y^4}{15z^2w}$
3. $\begin{cases} \frac{x^4-y^4}{x^2+xy} \div \frac{2^2+y^2}{x} = \frac{x^4-y^4}{x(x+y)} \times \frac{x}{x^2+y^2} \\ = \frac{x^2-y^2}{x+y} = x-y. \end{cases}$

DIVISION of *Surds*, is the method of ascertaining the quotient arising from the division of one irrational quantity by another. *Rule.* Reduce the given surds to their simplest form, and the radical parts thus arising to like radicals; then divide the co-efficient of the dividend by the co-efficient of the divisor for the new co-efficient, and one surd part by the other for the required surd, which being annexed with its proper radical sign to the co-efficient before found, will be the answer required. *Note.* If the radical signs be not the same, but the quantities under them be equal, the division will be effected by subtracting the index representing the radical of the divisor from the index of that representing the radical of the dividend.

Examples.

1. $\frac{\sqrt{105}}{\sqrt{7}} = \frac{\sqrt{735}}{7} = \frac{1}{7}\sqrt{735}$
2. $\frac{\sqrt{54x^4y}}{\sqrt{18x}} = \frac{3x^2\sqrt{6y}}{3\sqrt{2x}} = x^2\sqrt{\frac{3y}{x}} = x\sqrt{3xy}$
3. $\frac{\sqrt[3]{108}}{\sqrt{18}} = \frac{3\sqrt[3]{4}}{3\sqrt{2}} = \frac{\sqrt[3]{4}}{\sqrt{2}} = \frac{\sqrt[6]{16}}{\sqrt[6]{8}} = \sqrt[6]{2}$

Note. When the proposed divisor is a binomial surd, consisting of the sum or difference of two square roots, it may be rendered rational by multiplying both numerator and denominator, or, which is the same, both divisor and dividend, by the same two quantities, but connected with a contrary sign to that by which they are connected in the denominator, that is, by + when that is —; and by —, when that is +; because the product of the sum of two quantities multiplied by their difference, is equal to the difference of their squares. Thus, for example, required the quotient arising from the division of $\sqrt{5}+\sqrt{7}$ by $\sqrt{13}+\sqrt{10}$. By the rule,

$$\begin{cases} \frac{\sqrt{5}+\sqrt{7}}{\sqrt{13}+\sqrt{10}} = \frac{\sqrt{5}+\sqrt{7}}{\sqrt{13}+\sqrt{10}} = \frac{\sqrt{13}-\sqrt{10}}{\sqrt{13}-\sqrt{10}} \\ = \frac{\sqrt{65}+\sqrt{91}-5\sqrt{2}-\sqrt{70}.}{3} \end{cases}$$

DIVISION of *Ratios*, or *Divided Ratio*, is when of four proportional quantities, the differences of the antecedents and consequents are compared either with the antecedents or consequents; thus, if $a : b :: c : d$.

$$\text{then} \begin{cases} a-b : a :: c-d : c. \\ a-b : b :: c-d : d. \end{cases}$$

DIVISOR, is that number or quantity which exactly divides another number or quantity, without leaving a remainder. Divisor also signifies that number by which another number is to be divided, without regard to what may remain after division.

Common Divisor, in Arithmetic, is that number which will exactly divide two or more given numbers; and the greatest of all such divisors is called the greatest common divisor, or the greatest *common measure*. The following theorems are frequently useful in finding the divisors of numbers:—1. If the last digit of any number be divisible by 2, the whole number is divisible by 2. If the two last digits be divisible by 4, the whole number is divisible by 4. If the three last digits be divisible by 8, the whole number is divisible by 8. And generally, if the last *n* digits of any number be divisible by 2^n, the whole number is divisible by 2 . 2. If the sum of the digits of any number be divisible by 3 or by 9, the whole number is divisible by 3 or 9; and if also the last digit be even, the whole number is divisible by 18. 3. If a number terminate with 5, it is divisible by 5; and if it terminate in 0, it is divisible by either 10 or 5. 4. If the sums of the alternate digits be equal, or if one sum exceed the other by 11, or by any multiple of 11, the whole number is divisible by 11. See vol. i. p. 24, Euler's "Algebra," 2d English edition.

By means of these theorems we are enabled frequently to ascertain the divisors of numbers, but when the greatest common divisor of two numbers is required, we must proceed by the following rule.

To find the greatest common Divisors of two given Numbers.—*Rule.* Divide the greater number by the less, then divide the divisor by the remainder; and thus continue always dividing the last divisor by the last remainder till nothing remains, and the last divisor will be that required.—*Note.* If the greatest common divisor of three or more numbers be required, find the common divisor of two of them first, then of this common divisor and another of the given numbers, and so on to the last; so shall the last divisor be the greatest common divisor required.

Examples.—Required the greatest common divisor of 7631 and 26415.

7631) 26415 (3
22893

3522) 7631 (2
7044

greatest common divisor = 587) 3522 (6
3522

0

which number will divide both the given numbers, for

$$\frac{7631}{587} = 13; \text{ and } \frac{26415}{587} = 45.$$

Common Divisor, in Algebra, is any algebraical formula or expression, that will exactly divide two or more other algebraical formulæ, without leaving a remainder; and the greatest of such divisors is called the greatest common divisor.

DIVORCE, a separation of two de facto married together, of which there are two kinds; one a vinculo matrimonii, from the very bond of marriage; the other a mensa et thora, from bed and board.

DIURETICS, in Pharmacy, such medicines as increase the discharge of urine; or which are supposed to have a power of removing obstructions in the urinary passages.

DIURNAL, in Astronomy, any thing relating to the day, in opposition to nocturnal, relating to the night.

Diurnal *Arc*, is the apparent arc described by the heavenly bodies, in consequence of the rotation of the earth.

Diurnal *Motion* of a *Planet*, is the number of degrees, minutes, &c. which a planet moves in 24 hours.

Diurnal *Motion* of the *Earth*, is its rotation round its axis, the duration of which constitutes the natural day. This motion has generally been considered as uniform, though there have been some astronomers who have suspected a trifling irregularity; and the late investigations of the French astronomers tend rather to confirm the latter hypothesis.

DOCK, a broad and deep trench formed on the side of a harbour, or the banks of a river, and commodiously fitted, either to build ships, or to receive them to be repaired; these docks have generally strong flood-gates, to prevent the flux of the tide from entering the dock. There are likewise wet docks without flood-gates, where a ship can be cleaned during the recess of the tide, or between the times when the tide leaves her dry aground, and the period when it reaches her again.

DOCKING a Ship, the act of drawing her into dock, in order to give her a proper repair, cleanse the bottom, and cover it anew. *See* the article Breaming.

DOCKS, London, just below the site of the Tower, and on the left bank of the Thames, were begun in 1800, and completed in 1805, at an expense of £1,500,000 sterling; at any rate the capital of the Company is a million and a half sterling: the dividend, by act of parliament, can never exceed 10 per cent. The larger dock is a rectangle, the longer sides of which run from east to west. The lower entrance is by a cut which opens into a long basin, communicating with the dock by a short canal: this is called the Wapping entrance. Higher up the river, there is another canal, which leads to the south-west angle of the dock: this is the entrance called the Hermitage, of which we give a plan, with the excellent locks by which it is floated. For all these details, see the Plate London Docks. The late Mr. Rennie was the engineer who prepared the plans, and directed the execution of these great undertakings. To form an idea of the importance of these works, it will be sufficient to detail some of the principal dimensions.

The Dock, properly so called, is 420 yards in length, 276 yards in breadth, and 29 feet in depth; its superficies is equal to 25 acres; that of the basin is above two and a half acres; and if to this square be added the ground occupied by warehouses, the sheds, and the quays, it will be found that the whole premises contain a superficies of 110 acres. With the exception of those ships that trade to the East and West Indies, every vessel, whether English or foreign, may enter the London Dock, upon paying the duties, to unship their cargoes, or take in a new lading.

For the convenience of business, ranges of sheds, low, and of a very simple construction, have been erected along the sides of the dock and near the edges of the quays, into which cargoes are removed. Behind these sheds, and in a parallel direction to them, stands a line of magnificent warehouses, four stories high, with spacious vaults, into which the casks are conveyed by inclined planes. These warehouses are built with regularity and solidity, but without any pretension to ornaments. Nothing, however, can be more imposing than the effect of the whole, of the grandeur of which some idea may be formed, by considering that these buildings occupy a superficies of 120,000 square yards.

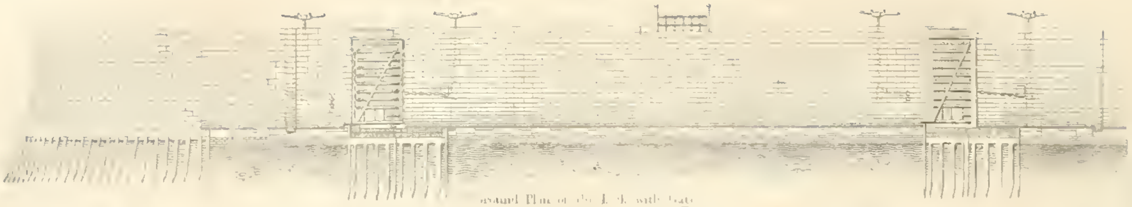
In front of the warehouses, and along the whole length of the sheds, are iron railways; others cross these at right angles, leading from the quay to the warehouses, and, in some instances, to their interior. Oblique lines of connexion facilitate the communication of the former railways with the latter. As the edges of these railways rise in a small degree only above the level of the pavement, carriages can pass over without damaging them, and without being impeded by them.

To the east of the dock, a range of warehouses has been built, for the reception of tobacco. Before this expensive production was stored in secure places, and defended by high walls, it was a great object of the system of plunder and fraud carried on upon the river. The first and most extensive of these warehouses, which of itself covers a space of six acres, is the work of Mr. Alexander. This distinguished architect has here made a most judicious combination of wood and iron. On the other side of a short canal, and close to this warehouse, is a second, which covers about 17,000 square yards. Its construction is evidently upon the same principle as the last mentioned. But in the present instance, the idea which Mr. Alexander afterward followed up, is in some measure still rude, and the progress of art is very perceptible in a comparison of the two buildings.

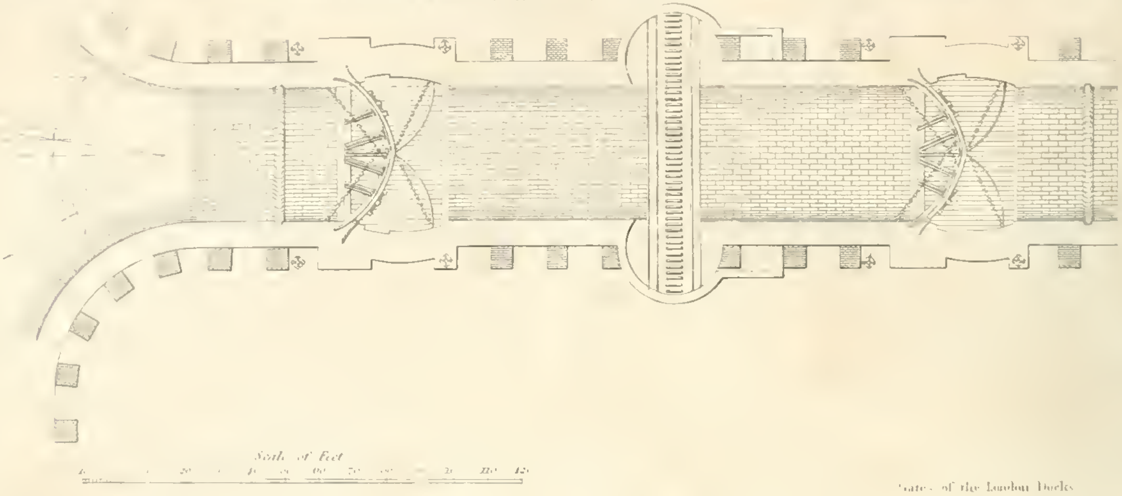
The London Docks are the grand depôt for foreign spirits: numerous pipes of wine and brandy are kept in the vaults, which occupy the same superficies as the warehouses; these

[illegible] D[illegible]

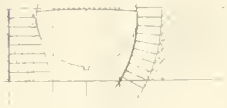
[illegible] Entrance to the London Do[illegible]



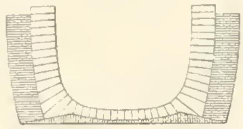
[illegible] Plan o[illegible] the L[illegible]k with Gate



Masonry

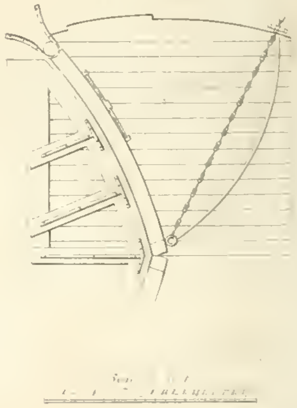


[illegible]nry

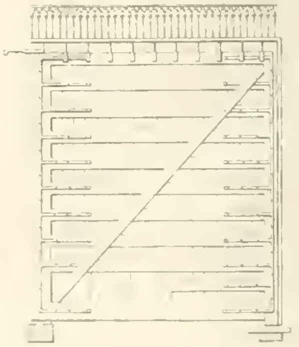


Gates of the London Docks

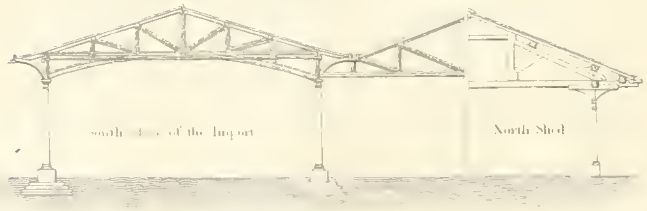
Ground Plan



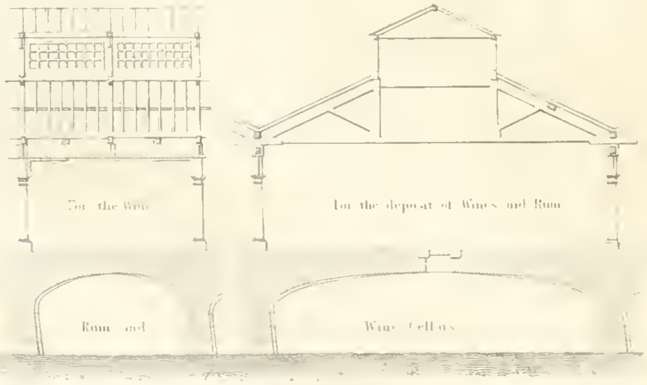
Elevation



[illegible] in the West India Docks



[illegible] built by J Rennie



vaults are groined, and their piers support the columns of the warehouses above.

The London Docks have their several parts perfectly adapted to each other, and are of the most admirable construction. The gates, like all those whose size exceeds from 20 to 23 feet, instead of being straight, are curved on the side on which the water presses.

Another very important difference observable between the hydraulic architecture of the English and that of the French, is the form of the walls of their quays. The French give the exterior face of these walls the straight form of an inclined plane, while the interior face, or that which is in contact with the ground, is in the form of a vertical plane. The English give both these faces a curved form, beginning almost perpendicularly, and without a curve at the upper part; the curvature increases, and takes a sloping direction, which is less rapid as it approaches the lower courses of the work. In works executed with great care and precision, these courses, instead of being horizontal, are perpendicular to the exterior surface of the wall.

The West India DOCKS are on the left bank of the Thames, at the distance of about one mile and a half below the London Docks; they are situated on the base of a tongue of land of the Isle of Dogs, a sort of peninsula formed by a long circuit of the river. The docks have an entrance at each extremity of this circuit. South of the docks, and parallel to their length, is the city canal, by means of which the long turn of the river may be avoided. But in order to gain the advantage offered by the canal, a toll is to be paid. Naval captains prefer following the common course of the river, which, when the tide serves, does not occasion a loss of more than two hours' time. It has been found more advantageous to make this canal serve as a receptacle for dismantled ships laid up in ordinary; they are ranged on a line of about a mile in length, and present a magnificent sight when viewed from the right bank of the river.

The West India docks are much superior to the London both in extent and regularity. These vast works were undertaken and executed by an association of private individuals, and by means of a mere subscription; twenty-seven months sufficed to accomplish the whole. The excavations of the West India docks began on the 12th of July, 1800; and as early as the month of September, 1802, vessels entered the import dock!

At the highest tides the depth of water in the two docks is twenty-four feet; they are formed parallel to each other; their common length is about 890 yards. The largest, which has a superficies of above thirty acres, is destined to those vessels returning to the West Indies, which deposit their cargoes in the warehouses of this artificial port. The second, the superficies of which is about twenty-five acres, receives the vessels laid up in ordinary, or taking the outward bound cargoes. These docks, with their basins, and the locks which connect them with the river, present an area of sixty-eight acres of ground, excavated by human hands, for the reception and moorage of vessels: the total superficies, including that of the quays and warehouses, is 140 acres.

During the busy season, this establishment employs about 2600 workmen. It can admit at the same time 204 vessels in the import, and 195 in the export dock, forming a total of 120,000 tons. During the first fifteen years, 7,260 vessels entered them. In fine, upon the quays, under the sheds, and in the warehouses, there have been deposited at the same time 148,563 barrels or casks of sugar, 70,875 barrels and 433,648 bags of coffee, 35,158 pipes of rum and Madeira wine, 14,021 logs of mahogany, 21,350 tons of logwood, &c. Nothing appears more simple than the idea of forming separate docks for the loading and unloading of importations and exportations, yet, infinite as the advantages which it affords are, in preventing confusion, and the frauds which it naturally produces, the English constructed docks for more than a century before the idea of separate docks struck them.

At the upper and lower entrances of the two docks, a basin presents three locks of communication. The first communicates with the Thames. The water is kept in it by means of double gates. The second and third locks lead respectively into the export and import docks; they have also double gates. By this means, the vessels are able to come in and go out independently of the state of the tide; they may remain in the basin as long as is judged convenient. The water of the docks being but very little higher than that of the basins, it does not press violently on the gates of the locks. It should be also observed, that this water having had time to settle in its previous passage through the basin, hardly deposits any sediment when introduced into the docks.

The docks lie in the direction of west to east, inclining a little towards the south. The principal entrance, that of the import dock, is in the midst of the smaller side to the west, which faces London; in coming from the city, we reach it by a branch of the Commercial Road.

William Jessop furnished the plans of the West India docks, and directed their execution—a monument which will perpetuate his memory. The construction which we have described, in speaking of the London dock, as to quays with concave linings, lock-gates forming a sweep, and iron bridges, was first put in practice in the establishment now under consideration. After the death of William Jessop, all these works were intrusted to J. Rennie, sen.

The sheds represented in our Plate, run parallel with the warehouses. The columns supporting them are eleven feet high, of cast iron, as are also the capitals; the construction of these roofs is very simple, but firm and neat.

The East India DOCKS belonging to the East India Company, are inferior to the West India docks in magnitude, but equal in point of construction, security of property, and, having to receive vessels of 2500 tons, they are deeper than the West India docks, and have never less than 23 or 24 feet water.

DOCK-YARDS, arsenals containing all sorts of naval stores and timber for ship-building. In England the royal dock-yards are at Chatham, Portsmouth, Plymouth, Deptford, Woolwich, and Sheerness, where his majesty's ships and vessels of war are generally moored during peace, and such as want repairing are taken into the docks, examined, and refitted for service. These yards are generally supplied from the northern crowns, with hemp, pitch, tar, rosin, canvass, oak plank, and several other species of stores. With regard to the masts, particularly those of the largest size, they are usually imported from New England. The three first of these yards are governed by a commissioner resident at the port, who superintends all the musters of the officers, artificers, and labourers, employed in the dock-yard and ordinary: he also controls their payment therein, examines their accounts, contracts and draws bills on the navy-office to supply the deficiency of stores; and, finally, regulates whatever belongs to the dock-yard, maintaining due order in the respective offices.

DOCTOR, a person who has passed all the degrees of a faculty, and is empowered to teach or practise the same: thus we say, doctor in divinity, doctor in physic, doctor of laws.

DODECAGON, in Geometry, a regular polygon, consisting of twelve equal sides and angles.

To inscribe a Dodecagon in a Circle.—Apply the radius of the circle six times round the circumference, which will divide it into six equal parts; then bisect each of those parts, which will divide the circumference into 12 parts for the dodecagon required.

To find the Area of a Dodecagon.—If the side of a dodecagon be 1, its area is equal to $3 + \tan. 75^\circ = 3\,(2 + \sqrt{3}) = 11\cdot1961524$ nearly: and as the areas of polygons are to each other as the square of their like sides, we have as

$1^2 : 11\cdot1961524 :: s^2 : s^2 + 11\cdot1961524 =$ the area of a dodecagon.

DODECAHEDRON, in Geometry, one of the regular Platonic bodies, comprehended under 12 equal sides or faces, each of which is a regular pentagon. Or, a dodecahedron may be conceived to consist of 12 equal pentagonal pyramids, whose vertices or tops all meet in one common point, which will be the centre of the sphere circumscribing the dodecahedron. The side of a dodecahedron, inscribed in a sphere, is equal to the greater part of the side of a cube inscribed in the same sphere when cut in extreme and mean proportion. If a line be cut in extreme and mean ratio, and the less part of it be taken for the side of a dodecahedron, the greater part will be the side of a cube inscribed in the same sphere. The side of the cube is equal to the right line that subtends the angle of the pentagon, which forms one of the equal sides of the dodecahedron, inscribed in the same sphere.

DODECATEMORY, the twelfth part of a circle. The term is chiefly applied to the twelve houses, or parts, of the zodiac, of the *primum mobile*, to distinguish them from the twelve signs; though some authors use the same term when speaking of the twelve signs of the zodiac, because they each contain a twelfth part of the whole circle.

DOG, a sort of iron hook or bar with a sharp fang at one end, so formed as to be easily driven into a piece of timber; it is used to drag it along by means of a rope fastened to it, upon which any number of men can pull, and so draw the plank towards the place where it is to be stowed. It is also used for the same purpose in unlading the ship.

DOGGER, a Dutch vessel navigated in the German ocean; it is equipped with two masts, a main and a mizzen-mast, and somewhat resembles a ketch. It is principally used for fishing on the Dogger Bank.

DOG-VANE, a small vane composed of thread, cork, and feathers, fastened on the end of a half-pike, and placed on the weather gun-wale to steer the ship by, when sailing on a wind.

DOLICHOS, a genus of the decandria order, in the diadelphia class of plants; and in the natural method ranking under the 32d order, papilionaceæ. There are 38 species, the most remarkable of which, the soja, a native of Japan, grows with an erect, slender, and hairy stalk to the height of about four feet. The leaves are like those of the garden kidney bean. The flowers are of a bluish white, and produced from the bosom of the leaves, and succeeded by bristly hanging pods resembling those of the yellow lupin, which commonly contain two, sometimes three, large white seeds. There is a variety of this kind, with a small black fruit, which was once employed in medicine. Kempfer affirms, that the seeds of this give relief in the asthma. From this plant comes the pickle called sooju or soy; to make which, they take equal quantities of the beans boiled, barley or wheat roughly ground, and common salt. Having properly mixed the beans with the pounded corn, they keep the whole covered in a warm place, in order to ferment; then putting the mass into a pot, they cover it with the salt, pouring over the whole two measures and a half of water. This they stir for two or three months, at the end of which time they filtrate and express the mass, and preserve the liquor in wooden vessels.

DOLLAR, a silver coinage of Spain and of the United States, the former being worth 4*s*. 5½*d*. of the coinage before 1772; and 4*s*. 4½*d*. since that date; which latter is also about the value of the American dollar.

DOLOMITE. There are several kinds. White dolomite contains 46.5 carbonate of magnesia, 52.08 carbonate of lime, 0.25 oxide of manganese, 0.5 oxide of iron. It is found in beds in the island of Iona. A beautiful variety, found in the island of Tenedos, was used by the ancient sculptors. It consists of fine granular concretions. The brown dolomite is the magnesian limestone of Tennant. There is a columnar dolomite of a pale grayish white. Compact dolomite is of a snow-white colour.

DOLPHIN, or Delphinus, in Astronomy, the *Dolphin*, one of the old constellations, which is said to have been placed among the constellations by Neptune, because by means of this fish, Amphitrite became the wife of Neptune, though she had made a vow to observe perpetual celibacy.—*Boundaries and Contents.* W. by Aquila, N. by Vulpecula, E. by Pegasus, and S. by Aquarius and Antinöus. This constellation contains 18 stars, five of which are of the 3d magnitude, and the rest of smaller magnitudes.

Dolphin *of the Mast*, a kind of wreath formed of plaited cordage, to be fastened occasionally round the mast as a support to the puddening; the use of which is to sustain the weight of the fore and main yards by the jears, in case the rigging or chains, by which those yards are suspended, should be shot away in the time of battle.

DOME, in Architecture, is a roof, or vault, rising from a circular, elliptic, or polygonal base, or plane; with a convexity outwards, or a concavity inwards, in such a manner, that all the horizontal sections made by planes will be similar figures round a vertical axis. Domes are denominated by the figures of the basis on which they are erected; and are therefore called *polygonal*, *circular*, or *elliptic* domes. *Circular* domes are of several kinds, as *spherical*, *spheroidal*, or *ellipsoidal*, *hyperboloidal*, *paraboloidal*, &c. Domes that rise higher than the radius of the base are called *surmounted domes*; and those which rise less than this dimension, are termed *diminished* or *surbased* domes. Domes that rise from circular bases are called also *cupolas*.

DOMESDAY, or Doomsday-book, a very ancient record made in the time of William the Conqueror, which now remains in the Exchequer, and consists of two volumes, a greater and a less; the greater contains a survey of all the lands in most of the counties in England, and the less comprehends some counties that were not then surveyed. The book of domesday was begun by five justices, assigned for that purpose in each county, in the year 1081, and finished in 1086. It was of that authority, that the Conqueror himself submitted, in some cases wherein he was concerned, to be determined by it. Camden calls this book the tax-book of king William; and it was farther called magna rolla. There is likewise a third book of domesday, made by command of the Conqueror; and also a fourth, being an abridgment of the other books.

DOMINICAL Letter, in Chronology, properly called Sunday letter, one of the seven letters of the alphabet A B C D E F G, used in almanacs, ephemerises, &c. to designate the Sundays throughout the year. In our almanacs, the first seven letters of the alphabet are commonly placed to shew on what days of the week the days of the months fall throughout the year. And because one of those seven letters must necessarily stand against Sunday, it is printed in a capital form, and called the dominical letter; the other six being inserted in different characters, to denote the other six days of the week. Now, since a common Julian year contains 365 days, if this number be divided by 7 (the number of days in a week) there will remain one day. If there had been no remainder, it is obvious the year would constantly begin on the same day of the week: but since one remains, it is plain that the year must begin and end on the same day of the week; and therefore the next year will begin on the day following. Hence, when January begins on Sunday, A is the dominical or Sunday letter for that year: then, because the next year begins on Monday, the Sunday will fall on the seventh day, to which is annexed the seventh letter G, which therefore will be the dominical letter for all that year: and as the third year will begin on Tuesday, the Sunday will fall on the sixth day; therefore F will be the Sunday letter for that year. Whence it is evident, that the Sunday letters will go annually in retrograde order thus, G, F, E, D, C, B, A. And, in the course of seven years, if they were all common ones, the same days of the week and dominical letters would return to the same days of the months. But because there are 366 days in a leap-year, if the number be divided by 7, there will remain two days over and above the 52 weeks of which the year consists. And, therefore, if the leap-year begins on Sunday, it will end on Monday; and as the year will begin on Tuesday, the first Sunday thereof must fall on the 6th of January, to which is annexed the letter F, and not G, as in common years. By this means, the leap-year returning every fourth year, the order of the dominical letters is interrupted; and the series cannot return to its first state till after four times seven, or 28 years; and then the same days of the months return in order to the same days of the week as before.

The dominical letter may be found universally, for any year of any century, thus: Divide the centuries by 4; and take twice what remains from 6; then add the remainder to the odd years above the even centuries, and their 4th. Divide their sum by 7, and the remainder taken from 7 will leave the number answering to the letter required. Thus, for the year 1878 the letter is F.

For the centuries, 18 divided by 4, leave 2; the double of which taken from 6 leaves 2 again; to which add the odd years 78, and their 4th part 19, the sum 99 divided by 7, leaves 1; which taken from 7, leaves 6, answering to F, the 6th letter in the alphabet.

DONATION, an act whereby a person transfers to another either the property or the use of something, as a free gift. In order to be valid, it supposes a capacity both in the donor and donee, and requires consent, acceptance, and delivery. Civilians distinguish donation into pure and conditional.

DONATIVE, in the Canon Law, is a benefice given by the patron to a priest, without presentation to the ordinary, and without institution or induction.

DONJON, in Fortification, signifies a strong stower, or redoubt of a fortress, whither the garrison may retreat, in case of necessity.

DONN, Benjamin, an English mathematician, lived at Biddeford, in Devonshire, in 1729. He kept a school in that town for some years, and, while there, made a complete survey of the county, for which he received a premium of £100 from the Society for promoting Arts and Commerce. In 1796 he was appointed master of mechanics to the king. He died in 1798, leaving behind him the character of an ingenious and worthy man.

DORIC Order. *See* Architecture.

Doric *Mode*, in Music, the first of the authentic modes of the ancients; its character is, to be severe, tempered with gravity and joy.

DORSIFEROUS Plants, among botanists, such as are of the capillary kind, without stalks, and which bear their seeds on the backside of their leaves.

DORSTENIA Contrayerva, a genus of the monogynia order, in the tetrandria class of plants; and in the natural method ranking under the 53d order, scabridæ. There are eight species, all of them low herbaceous plants, growing in the warm countries of America and China. The root is used in medicine, under the name of contrayerva. It has a kind of aromatic smell, and an astringent, warm, bitterish taste.

DOUBLE-BANKED, the situation of the oars of a boat, when two opposite ones are managed by rowers seated on the same bench or thwart; the oars are also said to be double-banked when there are two men labouring upon each oar.

DOUBLE-CAST, in Husbandry, a term used by the farmers for that method of sowing that does not dispense the necessary quantity of seeds for a piece of land at one sowing, but requires going over every place twice.

DOUBLE PLEA, in Law, is where the defendant in a suit alleges two several matters in bar of the plaintiff's action, when one of them is sufficient.

DOUBLING, in the Military art, is putting two ranks or files of soldiers into one.

DOUBLING A CAPE, is to sail round or pass beyond it, so as that the point of land separates the ship from her former situation, or lies between her and any distant observer.

DOUBLING Upon, in a naval engagement, the act of enclosing any part of a hostile fleet between two fires, or of cannonading it on both sides. It is usually performed by the van or rear of that fleet which is superior in number, taking the advantage of the wind, or of its situation and circumstances, and tacking or running round the van or rear of the enemy, who will thereby be exposed to great danger, and can scarcely avoid being thrown into a general confusion.

DOVE-TAILING, in Carpentry, is the fastening boards together by letting one piece into another, in the form of the tail of a dove. The dove-tail is the strongest of jointings, because the tenor, or piece of wood which is put into the other, goes widening to the extreme, so that it cannot be drawn out again.

DOWER, the portion which a widow hath of the lands of her husband, after his decease, for the sustenance of herself, and the education of her children.

Dower, *by the Common Law*, is a third part of such lands or tenements whereof the husband was sole seised in fee-simple, or fee-tail, during the marriage, which the wife is to enjoy during her life; for which there lies a writ of dower.

Dower *by Custom*. This kind of dower varies according to the custom and usage of the place, and it is to be governed accordingly; and where such custom prevails, the wife cannot wave the provision thereby made for her, and claim her thirds at common law, because all customs are equally ancient with the common law itself.

DOWN-HAUL, a rope passing up along a stay, through the cringles of the stay-sails or jib, and made fast to the upper corner of the sail, to pull it down when shortening sail.—*Down-Haul Tackles*, a complication of tackles employed to pull down the main or fore yard in a tempest, in order to reef the sail, because the violence of the wind prevents the weight of the yard from having its natural effect of descending.—*Down all Chests*, the order given to get all the officers' and seamens' chests down below from off the gun-decks, when clearing the ship for an engagement.—*Down all Hammocks*, the order for the sailors to carry their hammocks down, and hang them up in their respective births in readiness to go to bed.

DOWNS, a bank or elevation of sand, which the sea gathers and forms along its shores, and which serves it as a barrier.

Downs, is a term applicable also to vast tracts of naked poor land, on which sheep are usually grazed.

Downs, is particularly used for a famous road for ships along the eastern coast of Kent, from Dover to the North Foreland. This road has excellent anchorage, and is well defended by the castles of Sandwich, Deal, and Dover. The English fleets usually meet here.

DRABLER, an additional part of a sail, sometimes laced to the bottom of a bonnet on a square sail, in sloops and schooners.

DRABLING, in Angling, is a method of catching barbels. Take a strong line of six yards, which, before you fasten to your rod, must be put through a piece of lead, that if the fish bite it may slip to and fro, and that the water may somewhat move it on the ground; bait with a lob-worm well secured, that by its motion the barbel may be enticed without suspicion. The best places are in running waters near piles, or under wooden bridges, supported with oaks floated and slimy.

DRABS, in Salt-Works, a kind of wooden boxes for holding the salt when taken out of the boiling pan.

DRACHM, a Grecian coin, of the value of 7¾*d.* Drachm is also a weight containing sixty grains, three scruples, or the eighth part of an ounce.

DRACO, the *Dragon*, in Astronomy, represents, according to the fables of some of the poets, the monster which watched the garden of Hesperides. Others maintain, that in a war with the giants, this dragon was opposed to Minerva, who threw it round the axis of the earth, before it had time to unwind its contortions. Whoever attends to the situation of Draco, surrounding the Pole of the Ecliptic, will perceive that its tortuous folds are symbolical of the oblique course of the stars. Draco also winds around the Pole of the world, as if to indicate, in the symbolical language of Egyptian astronomy, the motion of the Pole of the Equator around the Pole of the Ecliptic, agreeably to the precession of the equinoxes and the moveable zodiac of the stars. The Egyptian hieroglyphic that represented the heavens was a *serpent*, whose scales denoted the stars; and Draco was the *Polar Constellation*, when Chaldea became the cradle of astronomy. The Greeks therefore did not invent this constellation.

Boundaries and Contents.—North by Cynosura and Cepheus, west by Cygnus and Lyra, south by Hercules, and east by Ursa Major. There are 80 stars in this constellation, *viz.* four of the 2d magnitude, seven of the 3d magnitude, and ten of the 4th, &c. α, situated between γ in the head of Draco and α in Ursa Major, is perhaps the most brilliant star in this constellation. 4620 years ago, α in Draco was the *Polar Star*. α having 209° 52′ 49″ right ascension, and 65° 14′ 20″ north declination, culminates at London, agreeably to the following table: Meridian Altitude 76° 86′ 40″ north.

Month.	Culm.	Month.	Culm.	Month.	Culm.
	ho. mi.		ho. mi.		ho. mi.
Jan.	7 15 M.	May	11 35 A.	Sept.	3 25 A.
Feb.	5 0 M.	June	9 30 A.	Oct.	1 35 A.
March	3 15 M.	July	7 30 A.	Nov.	11 40 M.
April	1 20 M.	Aug.	5 30 A.	Dec.	9 30 M.

Draco, the *Dragon*, in Zoology, a genus belonging to the order of amphibia reptilia. 1. The volans, or flying dragon, with the wings entirely distant from the forelegs. It is found in Africa and the East Indies. The præpos, with the wings fixed to the forelegs. It is a native of America. They are harmless creatures, and feed upon flies, ants, and small insects.

Draco Volans, in Meteorology, a fiery exhalation, frequent in marshy and cold countries. It is most common in summer, and though principally seen playing near the banks rivers, or in boggy places, yet sometimes it mounts to a co siderable height in the air, to the no small terror of the amazed beholders; its appearance being that of an oblong, or roundish, fiery body, with a long tail, but it does no injury.

DRACUNCULI, in Medicine, small long worms, which breed in the muscular parts of the arms and legs, called Guinea-worms, being common among the natives of Guinea. The worm is white, round, and uniform, resembling white round tape. It is lodged between the interstices and membranes of the muscles, where it insinuates itself, sometimes exceeding five ells in length. It occasions no great pain at the beginning; but at such times as it is ready to exit, the part adjoining to the extremity of the worm, where it attempts its exclusion, begins to swell, throb, and be inflamed; this generally happens about the ancle, leg, or thigh, and rarely higher. The countries where this distemper is observed are hot and sultry, liable to great droughts, and the inhabitants make use of stagnating and corrupted water, in which it is very probable that the ova of these animalculæ may be contained; for the white people who drink this water are obnoxious to the disease as well as the negroes.

DRAG, a machine consisting of a sharp square frame of iron encircled with a net, and commonly used to rake the mud off from the platform or bottom of the docks, or to clean rivers.

DRAGGING the Anchor, the act of trailing it along the bottom, after it is loosened from the ground by the effort of the wind or current.

DRAGON'S Head and Tail, are the nodes of the planets, but more particularly of the moon, being the points in which the ecliptic is intersected by her orbit, in the angle of about 5° 18′. One of these points is to the northward, the moon beginning then to have north latitude; and the other southward, where she commences south latitude; the former point being represented by the knot ☊ for the head, and the other by the same reversed, or ☋, for the tail. And near these points it is, that all eclipses of the sun and moon happen.

Dragon's *Blood*, a gummy resinous substance, which is brought from the East Indies. It is said to be obtained from the palmajuncus draco, the calamus rotang, the dracena draco, the pterocarpus draco, and other vegetables. In the present practice of medicine, it is very little, if at all, used, either externally or internally. A solution of dragon's blood in spirit of wine, is used for staining marble, to which it gives a red tinge.

Dragon *Shell*, in Natural History, a name given by people curious in shells to a species of concamerated patella or limpet. This has a top very much bent, and is of an ash-colour on the outside, but of an elegant and bright flesh-colour within. It has been found sticking on the back of a tortoise, as the common limpets do on the sides of rocks, and some have been affixed to large shells of the pinna marina.

DRAGOON, in Military affairs, a musketeer mounted on horseback, who sometimes fights or marches on foot, as occasion requires.

DRAINING, the art of clearing wet and boggy lands of their superfluous moisture. Land becomes charged with moisture from two causes:—1. From water collected in the higher grounds, and filtering among the different beds of gravel and other porous materials, forming springs below, and flowing over the surface, or stagnating underneath it. 2. From rain or water lodging and becoming stagnant on the surface, from the clayey or impervious nature of the soil, or superior stratum. The first of these causes bogs, swamps, and morasses, and is the most difficult to be remedied.

Springs are formed in the bowels of the earth, by water percolating through strata of a porous texture, and it continues to descend till it meets with a stratum of clay that intercepts it in its course, where, being collected in large quantities, it is forced to seek a passage through the strata of sand, gravel, or rock, that may be above the clay, following the course of them till they approach the surface of the earth, or are interrupted by any obstacle which occasions the water to rise, thus forming springs, bogs, &c. which being variously diversified, in different circumstances, produce that variety of appearances in this respect that we often meet with. This being the case, we may naturally conclude, that an abundant spring need never be expected in any country that is covered to a great depth with sand, without any stratum of clay to force it upwards, as is the case in the deserts of Arabia; neither are we to expect an abundant spring in any soil that consists of a uniform bed of clay from the surface to a great depth, for it must always be in some porous stratum that the water flows in abundance; and it can be made to flow horizontally in that only when it is supported by a stratum of clay, or other substance that is equally impermeable by water. Hence the *rationale* of that rule so universally established in digging for wells, that if you begin with sand or gravel, &c. you can seldom hope to find water till you come to clay; and if you begin with clay, you can hope for none in abundance till you reach to sand, gravel, or rock. It is necessary that the farmer should attend to this process of nature with care, in his practice of draining bogs, and every species of damp and spouting ground.

DRAMA, a Poem in which the action is represented. To the Greeks we owe the invention of both forms of dramatic composition, tragedy and comedy. These exhibitions were extremely simple. The action was continued from beginning to end, without pauses or intervals; there was no change of scene; and the attention of the spectators was continually occupied by the actors. The modern stage gives wider scope to the imagination, and renders the strict observance of the unities less necessary. The introduction of pauses by the division of acts justifies a change of scene, and also allows a longer extension of time, without any violation of probability. Thus a greater range of subjects for dramatic representation is provided, while at the same time, as the obstructions of art are removed, the mirror, if we may so express ourselves, becomes more true to nature. The poet may so construct his drama as to lead the imagination of his audience along with him, and thus may pass in review the striking events.

DRAPERY, in Sculpture and Painting, signifies the representation of the clothing of human figures, and also hangings, tapestry, and curtains.

DRASTIC, in Physic, a term applied to medicines which are potent in their operation, particularly cathartics.

DRAUGHT, in Trade, called also *Cloff* or *Clough*, is a small allowance on weighable goods, made by the king to the importer, or by the seller to the buyer, that the weight may hold out when the goods are weighed again. The king allows 1 lb. draught for goods weighing no less than 1 cwt.; 2 lb. for goods weighing between 1 and 2 cwt.; 3 lb. for goods weighing between 2 and 3 cwt.; 4 lb. from 3 to 10 cwt.; 7 lb. from 10 to 18 cwt.; 9 lb. from 18 to 30 cwt. or upwards.

Draught, the depth of a body of water necessary to float a ship; hence a ship is said to draw so many feet of water, when she is borne up by a column of water of that particular depth for instance, if it requires a body of water whose depth is equal to 12 feet, to float or buoy up a ship on its surface, she is said to draw 12 feet water; and that this draught may be more readily known, the feet are marked on the stem and stern-post from the keel upwards.

DRAUGHT-HOOKS, are large hooks of iron fixed on the checks of a gun-carriage, two on each side, one near the trunnion-hole, and the other at the train, for the convenience of drawing it backwards or forwards.

DRAWBACK, in Commerce, an allowance made to merchants on the re-exportation of certain goods, which in some cases consists of the whole, in others of a part of the duties which had been paid upon the importation. A still more equitable arrangement than that of drawbacks, is, to allow the merchant who imports any commodity which he may probably wish to export again, to deposit it in the king's warehouses, giving a bond for the payment of the duties, should he dispose of it for home consumption. This is called bonding, and is allowed to a considerable extent.

DRAWBRIDGE, a bridge made after the manner of a door, to draw up, or let down, as occasion serves, before the gate of a town or castle. *See* Bridge.

DRAWING, may properly be defined the art of giving a correct outline of any or every subject which has existence in nature; and it is by far, very far, the most difficult part in the formation of a picture. A correct outline will, without the assistance of any kind of shade or colour, convey to our minds the most accurate idea not only of a single subject, but of many

DRAWING.

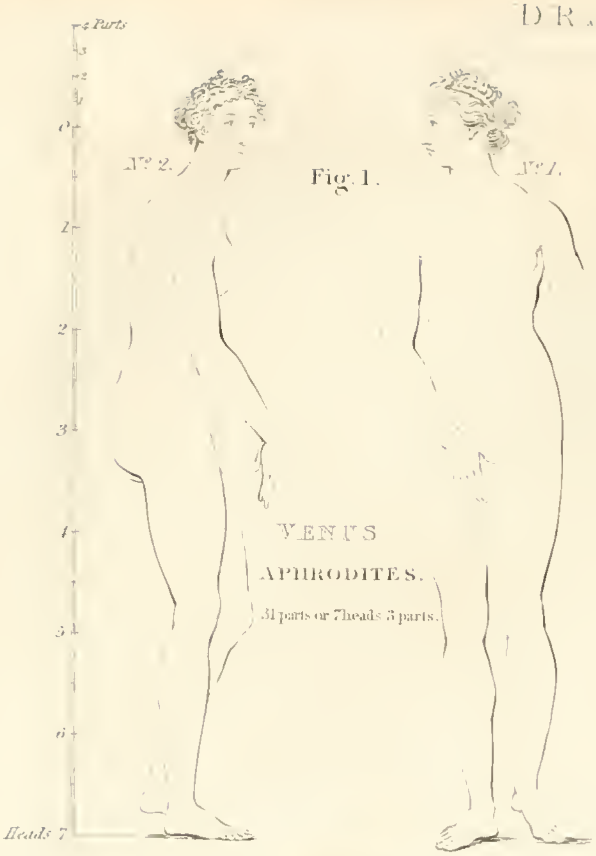


Fig. 1.

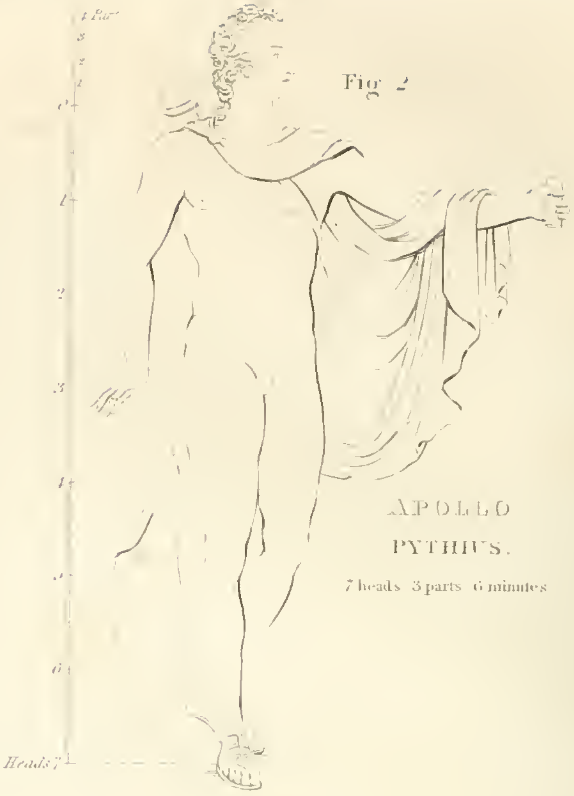


Fig. 2.

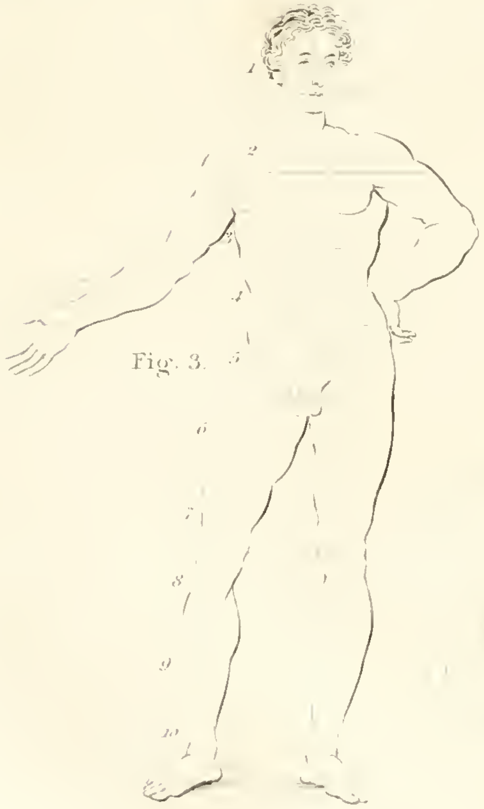


Fig. 3.

Fig. 4.

Fig. 5.

Fig. 6.

Nº 2.

Nº 1.

Fig. 7.

various objects assembled together, so that we shall be able to say, this is a correct likeness or resemblance of objects familiar to us, or of others which the mind's perception can embrace of objects which have never previously passed before its view, but which, from association, it can embody, fancy, or imagine as existing.

The precise time when this elegant art was first practised, cannot now be ascertained. That the earliest inhabitants of Egypt surpassed at one period all other nations in works of art, as well as in literary pursuits, no one can doubt that has dwelt upon the historic page. The remains of celestial Thebes, with her 1000 gates, and the paintings still in existence upon some of the walls of these gigantic monuments of the genius of former ages, are a convincing proof, that the Egyptians excelled the moderns in the art of fixing colours. While the paintings of more modern artists fade in a few years, and assume the sickly hue of age, theirs retain the glow and brilliancy of youth through the course of ages. But their finest specimens of drawing fall far short of the beauty and correctness of design of their successors and their rivals. The Egyptian outlines were, generally speaking, (though there are some exceptions, no doubt,) uncouth, preposterous, and unnatural: their sculpture also partook of these defects in the greatest possible degree; and while we gaze with almost speechless amazement at their stupendous architecture, and their ornamental statuary which adorns it—while we look with astonishment at the brilliancy of their coloured paintings, which remain unfaded to the present day, we look in vain for that fair proportion, beauty of design, and accurate skill, which characterize the less stupendous works of later artists.

Greece, immortal Greece, presents us with many remains of perfection in sculpture, but her paintings and her drawings have sunk into that gulf which alike consumes the works of the learner and the proficient. That the ancient Greeks excelled in painting, as well as sculpture, many are the records; but no trace is left of the works of Phidias, and, no doubt, of many other celebrated painters, whose works were cherished and highly prized by their admiring citizens. Fancy, or imagination, has given the merit of drawing to a Grecian lover, sitting by his mistress, who is supposed to have seized the idea of retaining her resemblance by tracing her likeness on a wall upon which her shadow fell. Enchanted with the thoughts of possessing that which would be to him an inexhaustible fund of happiness and pleasure, he carefully sketched the outline of that face he so much admired, and from that time forward practised the art of drawing with great success, opening to his highly-gifted mental countrymen a source of perpetual pleasure, and leading eventually to the cultivation of the more sublime art of Sculpture. Its origin is of little importance; our present duty is to give those instructions, or general rules, to those who wish to make it either a study or an amusement.

The first class of drawing is undoubtedly that of the human figure, the most difficult to excel in, and when done well, by far the most beautiful.

Landscape is the next class, and this should include all subjects of natural history, according to the peculiar character of the country or scene depicted. Birds, Beasts, Fishes, Insects, Reptiles, and Flowers, present, however, individual subjects of study to attain perfection, which requires both time, labour, and experience.

In the theory of all these different minor objects, trivial as they may appear, a knowledge of Perspective is necessary. Even the wings of a butterfly when flying, and the feet of a caterpillar when crawling, must be placed in a perspective view, for the insect either to fly or walk properly. This kind of perspective is not, perhaps, to be acquired so much by rule as by eye,—but there are certain *rules* which may be pointed out even for these, as necessary to give them an appearance of nature. Take the wings of a butterfly, which close perpendicularly, for instance, when the insect is in a quiescent state. If the two back wings were not drawn a *little* lower than those which are nearest to the spectator, the insect would strike every eye as possessing something unnatural in its construction, though the person who censured the performance might not be able to point out the defect which he blamed.

A correct outline will portray a countenance so accurately, that the likeness may be recognized by all who know the party represented. Of how much importance is it then to those who wish to excel in this delightful art, that they should devote their principal attention to drawing; and first of all we wish to assist the student, by laying before his observation those rules and proportions which time and experience have pronounced infallible, as guides to excellence in this enchanting art.

The Proportions of the Human Figure.—The head and face form the *scale* by which the figure is measured. A man's height is composed of seven heads and a half, and his arms, when extended, should measure the same length from one middle finger to the other. The head should be of an egg-shaped form, rather than an oval, as shewn in the Plate, *Drawing*, fig. 6, No. 1 and 2. This is to be divided into four equal parts, the eyes falling upon the middle line, No. 1, which divides it into the half. See figs. 2 and 3, which will together give the proportions of every part of the body; but it is necessary to observe, that in all these proportions some respect must be paid to the characters of the figures drawn, and that there is a difference in the proportions of a man and a woman, must be evident to every casual observer; and in order the better to give the learner a correct idea upon the subject, we shall subjoin a table of the proportions of the Apollo Pythius and the Venus Aphrodites.

Length of the Head and Trunk of the Body.	APOLLO.			VENUS.		
	Hs.	Pts.	Min.	Hs.	Pts.	Min.
From the top of the head to the bottom of the chin 4 parts, or	1	0	0	1	0	0
,, the bottom of the chin to the top of the sternum or breast-bone	0	1	7	0	1	8
,, the top of the sternum to the pit of the stomach	0	3	10	0	3	6
,, the pit of the stomach to the navel	0	2	10	0	2	7
,, the navel to the pubis	0	3	6	0	3	9
Length of the head and trunk of the body	3	3	9	3	3	6
Length of the Lower Extremities.						
From the pubis to the small of the thigh above the patella or knee-pan	1	2	6	1	2	3
,, the small of the thigh to the joint or middle of the knee	0	1	9	0	1	6
,, the joint of the knee to the small of the leg above the ancle	1	1	9	1	2	0
,, the top to the bottom of the ancle	0	1	0	0	1	0
,, the bottom of the ancle to the bottom of the heel	0	0	9	0	0	9
Length of the lower extremities	3	3	9	3	3	6
Length of the head and trunk as above	3	3	9	3	3	6
Total length of the figures	7	3	6	7	3	0
Length of the Fore Arm, or Upper Extremities.						
From the top of the shoulder to the elbow	1	2	3	1	2	3
,, the elbow to the hand	1	1	2	1	0	6
,, the joint of the hand to the root of the middle finger	0	1	8	0	1	6
,, the root to the tip of the middle finger	0	1	10	0	1	7
Length of the upper extremities	3	2	11	3	1	10
Breadth between the outward angles of the eyes	0	1	6	0	1	7
,, of the face at the temples	3	2	2	0	2	2
,, of the upper part of the neck	0	2	0	0	1	11
,, over the shoulders	0	0	0	1	3	8
,, of the body below the armpits	1	2	5	1	1	8
,, between the nipples	0	0	7	0	3	8
,, from the bottom of the chin to the horizontal line of the nipples	1	0	7	1	0	1
,, of the body at the small of the waist	1	1	0	1	0	8
,, over the loins, or os ilium	1	1	3	1	1	6
,, over the haunches, or tops of the thigh bones	1	1	5	1	2	3
,, of the thigh at the top	0	3	0	0	3	1
,, of the thigh below the middle	0	2	8½	0	2	7
,, of the thigh above the knee	0	1	8	0	2	0

	APOLLO.			VENUS.		
	Hs.	Pts.	Min.	Hs.	Pts.	Min.
Breadth of the leg below the knee	0	1	6	0	1	10
,, at the calf of the leg	0	2	4	0	2	3
,, below the calf	0	1	7	0	1	11½
,, above the ancle	0	1	2	0	1	2
,, of the ancle	0	1	4	0	1	3
,, below the ancle	0	1	1½	0	1	1
,, middle of the foot	0	1	4	0	1	3
,, at the roots of the toes	0	1	7	0	1	7
,, of the arm over the biceps muscle	0	1	8	0	1	9
,, of the arm over the elbow	0	1	6	0	1	-
,, of the arm below the elbow over the long supinator	0	1	10	0	1	7
,, of the wrist	0	1	1	0	1	0
,, of the hand over the first joint of the thumb	0	1	9	0	1	8
,, of the hands over the roots of the fingers	0	1	7	0	1	6
,, over the heads of the scapulæ or shoulder blades	1	2	0	1	1	4
Length of both arms and hands, each of the Apollo's being 3 h. 2 p. 11 m. and the Venus 3 h. 1 p. 5 m.	7	1	10	6	2	10
Breadth between the tips of the middle fingers of each hand when the arms are stretched out horizontally	8	3	10	8	0	2
Side View.						
Length from the top of the head to the shoulder	1	1	8	1	1	6
,, From the top of the shoulder to the loins above the hip	1	3	8	1	1	7
,, from the loins to the lower part of the hip	1	0	2	1	2	1
,, from the hip to the side of the knee, opposite to the top of the patilla	1	2	0	1	0	11
,, from the side of the knee to the bottom of the heel	2	0	5	2	0	11
Length of the figures	7	3	6	7	3	0
Thickness from the fore to the back part of the skull	0	3	6	0	3	4
,, from the rising of the nose to the tip of the ear	0	1	8½	0	1	6
,, from the upper part of the neck	0	2	0	0	1	11
,, from the breast to the back over the nipples	1	0	6	1	0	6
,, from the belly to the small of the back	0	3	6	0	3	7
,, from the belly above the navel to the back of the loins	0	3	9	1	0	2
,, from the bottom of the belly to the round of the hip	1	0	0	1	0	5
,, from the fore part of the thigh to the bottom of the hip	1	3	2	0	3	7
,, of the thigh, at the middle	0	3	3	0	3	6½
,, of the thigh above the knee	0	2	1	0	2	3
,, at the middle of the knee below the patella	0	2	1	0	2	2
,, of the leg below the knee	0	1	9	0	1	11
,, of the leg at the calf	0	1	8	0	1	9
,, of the leg at the ancle	0	1	5½	0	1	4
,, of the foot at the thickest part	0	0	0	0	0	3
,, length of the foot	1	0	6	1	0	4½
,, from the fore part of the bend of the foot to the lower and back part of the heel	0	0	0	0	2	2
,, of the arm over the biceps	0	2	0	0	1	9
,, over the elbow	0	1	6	0	1	6
,, below the elbow	0	1	5	0	1	7
,, at the wrist	0	1	1	0	0	11
,, below the joint of the wrist	0	1	6	0	0	10
,, of the hand at the roots of the fingers	0	0	5½	0	0	5
,, at the roots of the nails	0	0	3½	0	0	3

The figure of a child has been divided by artists into four, five, or six parts, the head forming one. In drawing the head of a child, two circles are formed, a larger and a smaller one, as in fig. 7; when the head looks up, the lower circle grows longer, as in fig. 5; when it looks down, it recedes, and therefore must necessarily diminish, as in fig. 4. But these proportions being given, some few observations still remain to be made. In figures which exhibit great strength and gigantic form, as the Farnesian Hercules for instance, the proportions are not always exact. The length of the foot of figures in general, is given as one-sixth of the figure; but in the Hercules it is rather more,—as in the Venus it is rather less. But here *judgment* must be called in to aid the practitioner, as in many other respects it must constitute one of the chief assistants towards perfection.

The head of the human figure is the most expressive part of it. Every other member may indicate some one passion,—the head expresses them all. Next to the head, the hands are the most eloquent members, and they give double effect to the meaning of the countenance, as few examples will convince us, that they all but speak. The hands clasped, the head inclining upward, this attitude, whether the subject be standing, kneeling, or sitting, instantly conveys to our mind *supplication*. The hands crossed upon the breast, with the same elevation of the head, denote wrapt devotion; the hands clasped upon the breast, and the head declining, denote pious resignation and submission. With the hands, in fact, we pray, beseech, reject, invite, dismiss, implore, approve, condemn, &c.; but the varying passions of the human face, the rapid workings of the soul, the tumultuous feelings of joy, love, anger, contempt, hate, disdain; the more compound feelings of jealousy, revenge, &c. these can only be portrayed by the face. Art may happily catch some of these feelings, varying expressions, but she can express but one passion at the same moment. Hence the painter who found it impossible to depict the workings of a father's heart, when Agamemnon stood by the altar at the sacrifice of Iphigenia, covered the royal mourner's face with his robe. The picture of the two misers, painted by the blacksmith of Antwerp, has most happily succeeded in expressing anxiety and joy at the same time in the face of the figure which is looking at the spectator. There is a scintillation in the eyes which bespeaks his joy and delight at the riches before him, but his countenance is nevertheless wonderfully expressive of his miserly anxiety.

Le Brun has endeavoured to give designs of all the passions but many of his heads upon this subject appear to be caricatures; at any rate, the total distortion, and forced violence, which every feature betrays in the heads designed to represent jealousy, hate, horror, and many others, are undoubtedly quite overdrawn. That the same face will be hardly recognized when tranquil, to be the same when under the workings of violent passion, cannot be denied; but that he has greatly outstepped nature in the transformation the passions make in the 'human face divine,' is equally not to be denied. Yet it is not our intention to depreciate the abilities of Monsieur Le Brun, but merely to refer the student to the study of *nature*, in preference to the models he has left of the passions. In exhibiting the passions, it is also necessary that the whole body should bear somewhat of the same character. How ridiculous would it be to place a head portraying rage, upon a body in a quiescent state. Besides which, rage may be displayed in more ways than one. The man of ungoverned temper throws himself into a thousand extravagant attitudes, extends his arms, makes rapid strides towards the object of his anger, his face reddens, &c. But the man in whom rage may be equally powerful, but who at the same time has acquired some degree of self-command, becomes pale, his countenance works, but his motions are rather restrained than violent; if he walks his step is firm, and his attitudes more terror-striking to the *mind* than those of the former, who excites fear for our immediate *personal* safety only. Again, the position of a man under the effect of terror and affright, may be depicted in more ways than one Sometimes fear deprives a man of the power of motion; sometimes he is urged to precipitate flight, and sometimes he falls prostrate to the ground. The expression of fear, as depicted in the *countenance*, should agree with each of these attitudes. There should, in fact, be a unison in the whole figure; all should be harmony: and as we are surrounded by human nature, actuated by all their passions, we have now only to become close observers of what passes around us, to acquire a knowledge of which is indispensable towards the attainment of that excellence which every artist should aspire to, and which the labours of the most aged artists still find evading their grasp, in some one shape or another. But this should act as a spur to the youthful student, rather than a curb.

Grace is another point of material and *essential* consequence for a beautiful outline; but here again judgment must be called to our aid, for that which would constitute *grace* in a Venus, would be any thing but *grace* if given to Minerva. The attitude of a judge, an orator, may be graceful, but it would be folly to think for an instant that their attitude should resemble that of a young Esquimaux Indian.* In the former, animated dignity would constitute grace,—in the latter, roundness of limb, muscular strength, and a light yet firm attitude, agreeably to the pursuit he was following, whether running, standing, &c. would constitute grace. That grace of motion has always been considered as one of the leading characteristics in female beauty, we have the sanction of the sweet Mantuan poet: in the 560th line of the first book of the Æneis, he says—

> " And by her *graceful walk*, the queen of love is known."

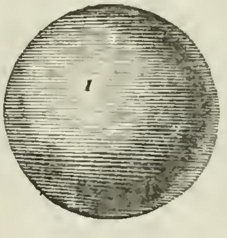
Beauty has been considered merely ideal. That it is so partly, is true; since the Negro and the Chinese differ as much in their ideas upon this subject, as they do with the Europeans, and other Asiatics. Yet we are not disposed to dispute with either of these nations the palm of female beauty; the small dark eyes of the one, and their fair skin and crippled feet, or the flat nose and prominent lips of the other, have no attractions for us. Every nation has a peculiar cast of countenance, and the most beautiful of the cast forms the *standard* national idea of beauty. If it were possible to place a beautiful woman from Italy, Spain, France, Germany, England, Holland, Circassia, Georgia, &c. side by side, we should be amused and enchanted beyond measure, for they would all possess a different style of beauty, yet each would still be *beautiful*. The artist, therefore, who intends to excel in historic painting, should be conversant with all these. How much the ideas of the ancients varied respecting beauty, may be seen from consulting their works, which still remain to us. The Venus de Medicis, Niobe, Ariadne, and the Antinöus, are matchless examples of beauty; yet how different are they! The Apollo de Belvidere is majesty personified; and who could look at the head only of the Farnesian Hercules, and not recognize *strength* as the leading feature of the whole statue?

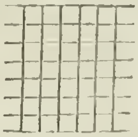
Costume, too, should occupy his attention—every part of his picture should harmonize. Even when designing stories from ancient times, the costume and manners of those times should be attended to; for if the subject is worth painting, it is surely worth painting well and accurately. Nothing should be considered unimportant which can illustrate the subject intended to be represented. It is not necessary for this purpose to crowd the design with a multitude of inferior objects or ornaments; but when such things are introduced, they should be in character. Simplicity of style partakes often of the sublime. To paint Cato in tinselled robes and gewgaws would be indeed absurd, yet there are subjects in which it would be equally absurd to omit them.

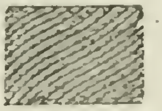
The intended artist must be aware, that before he can draw a whole figure, he must draw each feature and limb separately, and this is not to be slightly done, but from the best designs or models he can procure, with the greatest attention, till he is familiarized with every one of them. The hands and feet are particularly difficult, and require an infinity of practice: perhaps indeed perfection in the innumerable forms they take, is not to be acquired, except by those who study anatomical drawings. This is but little attended to by beginners, who are impatient to draw a "*whole length figure!*" foolishly imagining, that because they can make a heap of unmeaning eyes and noses, misshapen hands and feet, &c. they are fully competent to join them together, and having done so, they produce an ill-formed disgusting object, which in fact proves they are but " nature's journeymen who had made men, and not made them well, they imitated humanity so abominably." This should be reformed altogether. Drawing is a work of infinite labour. Genius may shew itself early, and produce fine wild sketches, prophetic of what may be done in future, but genius alone without study, never can produce a perfect work; it may and will sooner acquire perfection, but no excellence beneath the sun is to be attained without *labour*. This cannot be too deeply impressed upon the learner's mind. It would be advisable as one of the steps to freedom of drawing, to observe, that the pencil in *sketching* should be held at a greater distance from the point, than a pen in writing; and indeed longer than it is necessary to hold it in finishing. The hand, in sketching or drawing, should not rest on the ends of the two last fingers, as in writing; but it should not, if the drawing is large, touch the paper at all in making the first outline, and the palm of the hand should turn upwards nearly; in smaller drawings, not so much so, because it would be scarcely possible to steady the hand sufficiently to make minute touches without a support.† The artist should stand as much as possible at his studies, because standing is more generally conducive to health, than sitting and stooping over a desk for a continuation.

The materials for drawing are, lead pencil and chalk. Indian rubber should be used as little as possible, for two reasons—in the first place, it soils the paper when too frequently applied to it; and in the second, it gives an idle incorrect style of drawing, which should be most carefully avoided. The first sketch should be so light, that the last correction, and it should undergo many, should conceal it wholly. Correct subjects to copy from, and fine models, are indispensable.

With regard to the shading of figures without colour, two means are adopted; the one is accomplished thus: We give a round object, because it comprises light, shade, and reflection, decidedly. 1. Light. 2. Shade. 3. Reflection. If the eye be half closed, these three will be distinctly observed upon all round objects, whether long, as in a cylindrical form, or in a globe, or on a woman's arm, the roundness of which is not interrupted by strong muscular lines. Care should be taken, that the lines forming a shadow do not make squares, thus,—but rather thus, which lines harmonize, and do not offend the eye. *Fores'* drawing book gives excellent specimens of this shading, and the engravings are exact representations of what pencil and chalk shading *should* be, unless they are softened with a *stump*. The stump is principally applied to chalk drawing upon coloured paper. White chalk is then used to mark those prominent parts, which upon white paper would be left untouched.







As the student advances in his studies, he will find pleasure increase, and it is very seldom that the diligent and skilful remain in obscurity, when they have attained to a certain degree of excellence; but he should be content to be unknown till that period arrives. Diligently and secretly he must work his way, till he feels he may venture before a judicious, discerning, enlightened public.

With regard to Landscape Drawing, its foundation is perspective, (*see* PERSPECTIVE,) and its colouring must be drawn from nature, (*see* PAINTING.)

In drawing Flowers, the learner should copy first of all from

---

[*] When the late Mr. West first saw the Apollo Belvidere, he exclaimed, " How like a young Esquimaux Indian he looks!" The Italians were offended, till he assured them " he had seen an Esquimaux precisely in the same attitude when eager in his chase." West was an American by birth, but still we should fancy an Iroquois, or Canadian Indian, nearer the model than an Esquimaux.

[†] Artists frequently rest the arm on a piece of wood placed edgeways, when painting large pictures.

a sprig of laurel leaves, as the most simple in their formation, and their size requiring great freedom in the use of the pencil. Indeed, it would be an advantage to practise for some time mere lines of this description, since a combination of them in various ways will be found to produce most of the objects which surround us, that are not composed of straight lines.

Numerous have been the plans adopted by different artists to produce a brilliancy of effect in flowers. Some colours can only be procured by distillation; but in this the beginner must use his own powers of discrimination. Body colours for the leaves, have been frequently and strongly recommended, but body colour is not essentially and absolutely necessary, (of course we are speaking of water colours.) It is possible to produce the most accurate resemblance of nature by common water colours, but then this perfection must be attained by repeated attempts from *nature;* and flowers should be always placed in the *sun* when they are copied, because, as it is next to impossible ever to give the brilliancy of some flowers, (except in oil painting,) the stronger the *light*, and *shade*, and *colour* are in nature, at the moment the object is copied, the greater probability will there be that the drawing will be effective, than if deprived of these aids. White paint upon white flowers should be used sparingly; fine common chalk nicely pulverized with a little gum water, constitutes, perhaps, one of the best and most permanent white paints. Newman's "Constant White" is, however, an excellent article, but the ordinary "flake whites," &c. all turn black in time.

A perfect knowledge of colour can only be obtained by practice and the study of nature. Repetition day after day of the effect of the different colours when mixed, and the uses to which they may be applied, will give the rising artist that, which will in the end constitute an original and natural style of colouring. But, as it is supposed no beginner would presume to decide against the opinion of those whose instructions he is receiving, the above remarks are not intended to set the pupil in opposition to his master, but merely to impress upon the mind of the student, that to an artist's eye, every flower that blows, the largest or the smallest objects which surround him, whether a majestic tree or the smallest flower, whether a purling stream, a foaming torrent, a stagnant pool, or even the minute drop of glistening dew which trembles on the morning rose,—these, and millions of other objects, should be to him, not only sources of pleasure, but of intense attention and reflection.

Let him rise with the sun, and see how different the scene of a lovely landscape is, when the first *rosy* tints of morning appear—let him watch the varying hues which succeed as the vapours disperse and the golden orb advances—let him observe the *stillness*, the freshness of this season, and let him contrast it with the effects of a noon-day sun—then let him see the glorious orb sinking in golden purple floods of radiance. Still let him watch till the moon's pale beams throw her silvery lustre over the same sweet landscape, and let him mark the different effect of the same objects, in the same summer day! and view them again when the stormy clouds presage a tempest. Let him do this to the end of the chapter, and the youthful aspirant may, in time, become the renowned and celebrated artist. Whatever class of drawing or painting the artist chooses, *Nature* must still be his model, if he would attain perfection.

DREAMS have been described as the imaginations, fancies, or reveries of a sleeping man, and they are said to be deducible from the three following causes: 1. The impressions and ideas lately received, and particularly those of the preceding day. 2. The state of the body, particularly the stomach and brain; and, 3. Association. A Mr. Andrew Carmichael has started a very ingenious theory of dreaming. He enumerates no less than seven different states of sleeping and waking:—1. When the entire brain and nervous system are buried in sleep; then there is a total exemption from dreaming. 2. When some of the mental organs are awake, and all the senses are asleep; then dreams occur, and seem to be realities. 3. When the above condition exists, and the nerves of voluntary motion are also in a state of wakefulness; then may occur the rare phenomenon of somnambulism. 4. When one of the senses is awake, with some of the mental organs; then we may be conscious, during our dream, of its illusory nature. 5. When some of the mental organs are asleep, and two or more senses awake; then we can attend to external impressions, and notice the gradual departure of our slumbers. 6. When we are totally awake, and in full possession of all our faculties and powers. 7. When under these circumstances we are so occupied with mental operations as not to attend to the impressions of external objects; and then our reverie deludes us like a dream.

DREDGE, a kind of drag used with a long rope to catch oysters in deep water.

DRESSING OF ORES, the breaking and powdering them in the stamping-mill, and afterwards washing them in a wooden trough.

DRIFT, in Mining, a passage dug under the earth, betwixt shaft and shaft, or turn and turn; or a passage or way wrought under the earth, to the end of a meer of ground, or part of a meer.

DRIFT, the angle which the line of a ship's motion makes with the nearest meridian, when she drives with her side to the winds and waves, and is not governed by the power of the helm. It also implies the distance which the ship drives on that line. A ship's way is only called drift in a storm, and then when it blows so vehemently as to prevent her from carrying any sail, or at least restrain her to such a portion of sail as may be necessary to keep her sufficiently inclined to one side, that she may not be dismasted by her violent labouring, produced by the turbulence of the sea.

DRILL, in Mechanics, a small instrument for making such holes as cannot be done with punches.

DRILL, or *Drill-box,* a name given to an instrument for sowing land in the new method of horse-hoeing husbandry. *Drill sowing* is a method of sowing grain or seed of any kind, so that it may all be at a proper depth in the earth, which is necessary to its producing healthful and vigorous plants. For this purpose a variety of drill ploughs have been invented and recommended: but partly from the expense attending the purchase, partly from the complication of their structure, and partly from the attachment of the illiterate farmer to long habits, these schemes for diminishing labour have not received the encouragement to which they are entitled.

DRIVING, in the Sea-language, is said of a ship when an anchor being let fall will not hold her fast, nor prevent her sailing away with the tide or wind.

DROMEDARY, or ARABIAN CAMEL, is distinguishable from every other species of camel by having a single bunch upon the middle of its back. This animal, which is a native of many of the deserts of Asia and Africa, is of a tawny gray colour, and has soft hair, which is longer on the neck, under the throat, and on the bunch, than elsewhere. The Arabian, like all other species of camel, has its upper lip cleft, and its feet with two long hoofs, on which it treads, and two others shorter, which do not touch the ground. These animals constitute the principal source of riches, and the whole force and security, of the Arabians. They are the only beasts by which the inhabitants of the sandy deserts of many parts of Asia could travel or convey their burdens. The caravans of merchants, which traverse in all directions the deserts of Egypt and Arabia, are accompanied by camels, that are often more in number than the men. These commercial travels are sometimes to the distance of 700 or 800 leagues, and are usually performed at the rate of ten or twelve leagues a day, the camels being every night unloaded to rest and feed. The burden of each camel usually weighs about half a ton, and at the command of his conductor he kneels down, for the greater convenience of being loaded. The pace of the camel is a high and swinging trot, which to persons unaccustomed to it is at first disagreeable and apparently dangerous, but is afterwards sufficiently pleasant and secure. The Arabians in general ride on a saddle that is hollowed in the middle, and has at each bow a piece of wood placed upright, or sometimes horizontally, by which the rider keeps himself in the seat. A ring is inserted into the nostrils of the camel, to which a cord is affixed; and this serves as a bridle to guide and stop him, or to make him kneel when the rider wishes to dismount. In the caravans of one of the Abyssinian tribes, the people, armed with javelins, sometimes ride two together on each camel, and sit back to back.

The camels of Sahara are probably more fleet than any that are known; and on these animals the Arabs, with their loins, breast, and ears bound round, to prevent the injurious effects of percussion from the quickness of motion, can cross that great desert in a few days. With a goat's skin or a porous earthen pitcher filled with water, a few dates, and some ground barley, the Arab travels from Timbuctoo to Morocco, feeding his camel but once upon the road. In one instance a camel was known to travel from Fort St. Joseph, on the river Senegal, to the house of Messrs. Cabane and Depras at Mogador, a distance of more than 1000 miles, in seven days.

The *hair*, or fleece, of these animals, which is renewed every year, and which regularly falls off in the spring, is so soft, that the finest parts of it may be manufactured into stuffs of beautiful texture; and in Europe, when mixed with the fur of the beaver, it is sometimes made into hats. The inhabitants of some parts of Sahara live in tents of woven camel's hair, which forms a thick covering completely water-proof. After the hair has been stripped off, the *skin* is converted into leather. In Arabia, the *milk* of the camel is a most important article of nutriment; and the *flesh*, though dry and hard, is not unpalatable, particularly when young. By the inhabitants of Egypt this is so much esteemed, that, in Cairo and Alexandria, it was formerly forbidden to be sold to the Christians. In many parts of Africa the *tongues* are salted and dried, both for use and exportation; and with the ancient Romans the heels of camels were eaten as a great delicacy.

The Bactrian, or *Two-bunched Camel*, is known from the Arabian species by having two bunches on its back, by being somewhat larger, and having shorter legs. This animal is found in Usbec Tartary, the ancient Bactria: it is likewise a native of Siberia, Thibet, and some parts of China. The purposes to which the Bactrian camel are applied, are the same as those already described respecting the Arabian species. These animals, however, are sufficiently hardy to sustain the climate of the temperate parts of Siberia, and to be able, without injury, to traverse even humid and marshy countries, which would soon prove fatal to the Arabian camel.

DRONE, in Music, the largest tube of the bagpipe; the office of which is to emit one continued deep note, as an accompanying bass to the air or tune played on the smaller pipes.

DROPS, in Meteorology, small spherical bodies which the particles of fluids spontaneously form themselves into, when let fall from any height. This spherical figure, the Newtonian philosophers demonstrate to be the effect of corpuscular attraction.

DROPSY, in Medicine, an unnatural collection of watery humours in any part of the body.

DROWNING, signifies the extinction of life by immersion in water. Various plans for the recovery of drowned persons have been given, but the most tried and approved is that of the Royal Humane Society, as follows:

1. When the patient is taken out of the water, the wet clothes should be taken off with all possible expedition on the spot (unless some convenient house is near,) and a great coat or two, or some blankets, wrapped round the body.

2. The patient is to be carefully conveyed in the arms of three or four men to the nearest house, where, if in the winter season, a good fire, and a warm bed, can be made ready for its reception. As the body is conveying to this place, great attention is to be paid to the position of the head; which must be kept supported in a natural and easy posture, and not suffered to hang down.

3. In cold or moist weather, the patient is to be laid on a mattress or bed before the fire, but not too near, or in a moderately heated room; in warm and sultry weather, on a bed only. The body is then to be wrapped as expeditiously as possible with a blanket, and thoroughly dried with warm coarse cloths or flannels.

4. In summer or sultry weather, too much air cannot be admitted. For this reason it will be necessary to set open the windows and doors.

5. Not more than six persons are to be present to apply the proper means; a greater number will be useless, and may prevent the restoration of life, by rendering the air of the apartment unwholesome.

6. It will be proper for one of the assistants, with a common pair of bellows, applying the pipe a little up one nostril, to blow with force, to introduce air into the lungs; at the same time the other nostril and the mouth are to be closed by another assistant, while a third person gently presses the chest with his hands, after the lungs are inflated. If the pipe of the bellows is too large, the air may be blown in at the mouth, the nostrils being closed, so that it may not escape that way.

7. Let the body be gently rubbed with flannels, sprinkled with spirits. A warming pan heated (the body being surrounded with flannel) may be lightly moved up and down the back. Fomentations of hot brandy are to be applied to the pit of the stomach, loins, &c., and often renewed. Bottles filled with hot water, heated tiles covered with flannel, or hot bricks, may be applied to the soles of the feet, palms of the hand, and other parts of the body. The temples may be rubbed with spirits of hartshorn, and the nostrils now and then tickled with a feather; and snuff, or eau-de-luce, should be occasionally applied.

8. Tobacco-fumes should be thrown up the fundament: if a fumigator is not at hand, a common pipe may answer the purpose. This operation should be frequently performed, for the good effects of this process have been experienced in a variety of instances. But should the application of tobacco-smoke in this way not be immediately convenient, or other impediments arise, clysters of this herb, or other acrid infusions with salt, &c., may be thrown up with advantage.

9. When these means have been employed a considerable time without success, and a brewhouse is near, or a warm bath can be readily obtained, the body should be carefully conveyed to such place, and remain in the bath, or surrounded with warm grains, for three or four hours. If a child has been drowned, its body should be wiped dry, and placed in bed between two healthy persons. The salutary effects of the natural warmth, conveyed in this manner, have been proved in a variety of cases.

10. While the various methods of treatment are employed, the body is to be shaken every ten minutes, to render the process of animation more successful; and children are to be much agitated, by taking hold of their legs and arms frequently and for some time.

11. If there are any signs of returning life, a spoonful of warm liquid may be given; and if the act of swallowing can be performed, a cordial of warm brandy or wine may be given in small quantities, and frequently repeated.

12. Electricity may be tried by the skilful, as its application neither prevents nor retards the various modes of recovery already recommended; but, on the other hand, it will most probably tend to render the other means employed more expeditiously efficacious.

The methods which have been described, are to be employed with vigour for three hours or upwards, although no favourable circumstances should arise; for it is a dangerous error to suppose that persons are irrecoverable, because life does not soon make its appearance. Bleeding is never to be employed unless by direction of a medical person.

DRUG, a general term for goods of the druggist and grocery kinds, especially for those used in medicine and dyeing.

DRUGGET, in Commerce, a stuff sometimes all wool, and sometimes half wool, half thread; it is either corded or plain.

DRUIDS, the priests or ministers of religion of the ancient Britons and Gauls. The druids were chosen out of the best families; and were held, both by the honours of their birth and their office, in the greatest veneration. They are said to have understood astrology, geometry, natural history, politics, and geography: they had the administration of sacred things, were the expounders of religion, and the judges of civil affairs.

DRUM, a martial musical instrument in form of a cylinder, hollow within, and covered at the two ends with vellum, which is stretched or slackened at pleasure by small cords and sliding knots. Some drums are made of brass, but they are commonly of wood. Kettle drums are large basins of copper or brass, rounded in the bottom, and covered with vellum or goat-skin.

DRY-ROT, a term or name applied to a rapid decay of any vegetable matter, when it has the appearance of being tolerably dry, but in general is applied only to timber when in that state, and is so named in contradistinction to the common mode of decay, by being exposed to the alternate states of wet and dry. There are a great number of causes for this species of decay: some are quite simple; others very complicated; yet whatever may be the original cause, simple or compound, the effects are the same, namely, to render the timber useless, by destroying its elasticity and toughness, rendering it insufficient to resist any considerable pressure, and, indeed, for any of the useful purposes to which timber is applied. When timber is in a tolerably dry state, any means which will absorb or extract its oxygen from the other component parts will leave it in the state commonly called *dry rotten*. Moist, warm situations, with little or no current of air, are the most likely to generate this evil. The effluvia from timber in such a state of decay will rapidly carry its effects to the circumjacent timber, however dry it may appear, and any sort of timber will be in a very little time rendered quite useless. When timber is exposed to any considerable degree of moisture and heat, fungi of various shapes and texture, according to the species of timber, and other causes, will appear upon it; and although this fungous matter be really an effect of the *dry-rot*, yet it is as truly a cause of the same evil. There are no possible means of restoring rotten timber to a sound state, and the *dry-rot* can only be cured, as it is called, by removing the decayed and affected parts, clearing away all the fungi, and destroying its vegetating principle, with which the hard materials, such as bricks or stone, may have been impregnated. For this purpose, a strong solution of iron, copper, or zinc, is used with advantage. This, with the admission of a large quantity of air, is very advantageous. Many persons have written on the subject, and the nostrums proposed are as numerous as their authors. Timber once injured cannot be restored; but the evil may be stopped by removing the corrupted and contagious matter, and by the admission of a free circulation of air. Much also may be done by cutting timber in winter, and properly seasoning it by steeping it in water for some time, and then thoroughly drying it before it is used in building.

DUCAT, a coin current in Germany, and other countries abroad. In Germany, Italy, and Holland, it is of the value of about 9*s.* 3*d.*; the ducat of Naples is 3*s.* 4*d.*; that of Florence or Leghorn, 5*s.* 4*d.*; the gold ducat of Portugal is £6. 15*s.*

DUCATOON, a coinage in Holland and Flanders; in the former country its value is 5*s.* 6*d.* and in the latter 5*s.* 2½*d.*

DUCHY COURT, a court of the duchy-chamber of Lancaster, held at Westminster before the chancellor of the same, for matters concerning the lands and franchises of that duchy. The proceedings in this court are by English bill, as in chancery. Gwyn says, that this court grew out of the grant of king Edward III. who gave the duchy to John of Gaunt, and endowed it with royal rights and privileges; several others of our ancient kings likewise separated this duchy from the crown, and settled it in the natural persons of themselves and their heirs; though, in succeeding times, it was united to the crown again.

DUCTILITY, the extensibility and cohesion of particles, which enables metal to be drawn into wire without breaking. There is but a shade of difference between this property and that of malleability. The ductility of some bodies, especially of gold, is very surprising: the gold-beaters and wire-drawers furnish us with abundant proofs of this property; they every day reduce gold into lamellæ inconceivably thin, yet without the least aperture or pore discoverable, even by the microscope; a single grain of gold may be stretched under the hammer into a leaf that will cover a house, and yet the leaf remain so compact as not to transmit the rays of light, nor even admit spirit of wine to transude.

But M. Reaumur has carried the ductility of gold to a still greater extent. What is called gold-wire, every body knows, is only a silver one gilt. The cylinder of silver, covered with leaf gold, they draw through the hole of an iron, and the gilding still keeps pace with the wire, stretch it to what length they can. Now M. Reaumur shews, that in the common way of drawing gold wire, a cylinder of silver twenty-two inches long, and fifteen lines in diameter, is stretched to 1,163,520 feet, or is 634,692 lines longer than before, which amounts to about ninety-seven leagues. To wind this thread on silk for use, they first flatten it, in doing which it stretches at least one-seventh farther, so that the twenty-two inches are now 111 leagues; but in the flattening, instead of one-seventh, they could stretch it one-fourth, which would bring it to 120 leagues. This appears a prodigious extension, and yet it is nothing to what this gentleman has proved gold to be capable of.

Ductility *of Glass.* We all know, that when penetrated with the heat of the fire, the workmen can figure and manage glass like soft wax; but what is more remarkable, it may be drawn, or spun out, into threads exceedingly long and fine. Our ordinary spinners do not form their threads of silk, flax, or the like, with half the ease and expedition the glass-spinners do threads of this brittle matter. We have some of them used in plumes for children's heads, and divers other works, much finer than any hair, and which bend and wave like hair with every wind. Nothing is more simple and easy than the method of making them. There are two workmen employed; the first holds one end of a piece of glass over the flame of a lamp, and when the heat has softened it, a second operator applies a glass hook to the metal thus in fusion; and withdrawing the hook again, it brings with it a thread of glass, which still adheres to the mass; then fitting his hook on the circumference of a wheel about two feet and a half in diameter, he turns the wheel as fast as he pleases, which drawing out the thread, winds it on its rim, till, after a certain number of revolutions, it is covered with a skein of glass-thread. The mass in fusion over the lamp diminishes insensibly, being wound out like a clue of silk upon the wheel; and the parts, as they recede from the flame, cooling, become more coherent to those next to them, and this by degrees: the parts nearest the fire are always the least coherent, and of consequence, must give way to the effort the rest make to draw them towards the wheel. The circumference of these threads is usually a flat oval, being three or four times as broad as thick; some of them seem scarcely bigger than the thread of a silk-worm, and are surprisingly flexible. If the two ends of such threads are knotted together, they may be drawn and bent till the aperture, or space in the middle of the knot, does not exceed one-fourth of a line, or one-forty-eighth of an inch, in diameter. Hence the flexibility of glass increases in proportion to the fineness of the threads; and probably, had we but the art of drawing threads as fine as a spider's web, we might weave stuffs and cloths of them for wear, but could never make them long enough to be serviceable. *See* Divisibility.

DUEL, a single combat, at a time and place appointed, in consequence of a challenge. This custom came originally from the northern nations. Both the accuser and the accused gave pledges to the judges on their respective behalf; and the custom prevailed that none were excused from it but women, sick people, cripples, and such as were under 21 years of age, or above 60. Even ecclesiastics, priests, and monks, were obliged to find champions to fight in their stead. The punishment of the vanquished was either death by hanging or beheading; or mutilation of members, according to the circumstances of the case. Duels were at first admitted, not only on criminal occasions, but on some civil ones, for the maintenance of rights to estates, and before the like: in later times, however, they were almost entirely abolished, being restrained to these four cases: 1. That the crime should be capital. 2. That it should be certain the crime was perpetrated. 3. The accused must, by common fame, be supposed guilty. And, 4. The matter not capable of proof by witnesses. But this also has been abolished, and there no longer exists the "trial by battle."

Duel, at present is used for a single combat on some private quarrel, and must be premeditated, otherwise it is called a rencounter. If a person be killed in a duel, both the principals and seconds are guilty of murder, whether the seconds engage or not. It is also a very high offence to challenge a person either by word or letter, or to be the messenger of a challenge.

DUET, in Music, a composition written for two voices or instruments, with or without a bass and accompaniments.

DUKE, is either the title of a sovereign prince, as the Duke of Modena, the Grand Duke of Tuscany, &c. or it is the title of honour and nobility next below princes. Duke, at present in Britain, is a mere title of dignity, without giving any domain, territory, or jurisdiction, over the place from whence the title is taken. A duke is created by patent, cincture of sword, mantle of state, imposition of a cap and coronet of gold on his head, and a verge of gold put into his hand. His title is, Grace; and, in the style of the heralds, Most high potent, high-born, and noble prince.

DULCIMER, a musical instrument, strung with about fifty wires cast over a bridge at each end. It is performed upon by striking the wires with little iron rods.

DUMBNESS, the privation of speech, the most general cause of which is the want of the sense of hearing; language being originally acquired by imitating sounds. From this source of intelligence deaf people are entirely excluded; they cannot acquire articulate sounds by the ear: unless therefore articulation be communicated by some other medium, they must be deprived of language. Of late years it has been shewn, that though deaf people cannot learn to speak or read by the direction of the ear, there are other sources of imitation, by which the same effect may be produced. The organs of hearing and speech have little connexion. Persons deprived of the former generally possess the latter in such perfection, that nothing further is necessary to make them articulate, than to teach them how to use these organs. This, indeed, is no easy task, but it is practicable. The first thing is, to teach the pupil to pronounce the simple sounds of the vowels and consonants. The teacher pronounces the sound of the letter *a* very slowly, pointing to the figure of it upon paper at the same time, and makes the pupil observe the motion of his mouth and throat. He then puts his finger into his pupil's mouth, depresses or elevates the tongue, and makes him keep the parts in that position; then he lays hold of the outside of the throat, and applies such a kind of pressure as shall indicate to the pupil a certain necessary action to be performed by the muscles. All the while he is pronouncing *a*, the pupil is anxiously imitating him, but at first seems not to understand what he would have him to do. In this manner he proceeds, till the pupil has learned to pronounce the sounds of the letters. He goes on in the same manner to join a vowel and a consonant, till at length the pupil is enabled both to speak and to read.

DUODECIMALS, or CROSS MULTIPLICATION, (from *duodecem*, *twelve*,) is a rule used by workmen and artificers in computing the content of their work; dimensions are usually taken in feet, inches, and parts; but of the last, all those less than ¼ of inches are frequently omitted as of little or no consequence, and the same is always done in casting up the contents, where they are of still less importance.—*Rule.* Set down the two dimensions to be multiplied together under each other, so that feet may stand under feet, inches under inches, and parts under parts. Then multiply each term in the multiplicand, beginning at the lowest, by the feet in the multiplier, and set the result of each directly under its corresponding term, observing to carry 1 for every 12, from the parts to the inches, and from the inches to the feet. In like manner, multiply all the multiplicand by the inches and parts of the multiplier, and set the result of each, one remove to the right-hand of those in the multiplicand, and the sum of these successive products will be the answer. Or, instead of multiplying by the inches and parts, such parts of the multiplicand may be taken as these are of a foot.——*Examples.* Multiply 6 feet, 4 inches, 3 parts, by 10 feet, 3 inches, 9 parts.

	ft.	*in.*	*p.*		
	6	4	3		
	10	3	9		
	63	6	6		
	1	7	0	9	
		4	9	2	3
feet	65	6	3 answer.		

Otherwise;

	ft.	*in.*	*p.*
3 in. = ¼	6	4	3
	10	3	9
	63	6	6
9 p. = ¼	1	7	0¾
		4	9 3/16
feet	65	6	3 15/16

It may not be amiss to observe here, that the feet in the answer are square feet, but the numbers standing in the place of inches are not square inches, as one might at first infer, but 12th parts of square feet, each part being equal to 12 square inches. In like manner, the numbers standing in the third place, or place of parts, are so many 12th parts of the preceding denomination, these therefore are square inches; and in the same manner, if the operation be carried farther, every successive place will be a 12th part of that preceding it.

DUODECIMO, is used to denote the size of a book when the sheets are folded into twelve leaves.

DUODECUPLE, consisting of twelves.

DUODENARY ARITHMETIC, is that in which the local value of the figures increases in a twelvefold proportion from right to left, instead of the tenfold proportion in the common or denary arithmetic. Thus 1111, in the duodenary scale, expresses $12^3 + 12^2 + 12 + 1 = 1885$ in the common scale. Every number may be converted from one scale to the other, and in many cases the duodenary system (particularly after practice has rendered it familiar) possesses considerable advantages over that in common use. In the duodenary scale of notation, there must be introduced two new characters for expressing 10 and 11, and these may be represented by ϕ and π, that is $10 = \phi$; $11 = \pi$; so that the digits of this system become,

$$0, 1, 2, 3, 4, 5, 6, 7, 8, 9, \phi, \pi,$$

with which characters any number whatever may be expressed according to the duodenary system, the same as in common arithmetic, by the nine simple digits.

DUPLE, among Mathematicians, denotes the ratio of 2 to 1. Thus the ratio of 8 to 4 is duple, or as 2 to 1. *Sub*-DUPLE *Ratio* is just the reverse of the former, or as 1 to 2.

DUPLICATE, among Lawyers, denotes a copy of any deed, writing, or account. It is also used for a second letter written and sent to the same party and purpose as a former.

DUPLICATE *Proportion*, is a compound of two ratios; thus, the duplicate ratio of *a* to *b*, is the ratio of *a a* to *b b*, or of the square of *a* to the square of *b*.

DUPLICATION, in general, signifies the doubling of any thing or multiplying of it by 2; also the folding of any thing back again on itself.

DURATE, in Music, a term properly applicable to whatever offends the ear by its effect.

DURESS, in Law, is where a man is kept in prison, or restrained of his liberty, contrary to the order of the law.

DUTY, in Policy and Commerce, signifies the impost laid on merchandises, at importation or exportation, commonly called the duties of customs; also the taxes of excise, stamp-duties, &c.

DYE, in Architecture, any square body, as the trunk, or notched part of a pedestal; also a cube of stone placed under the feet of a statue, and over its pedestal.

DYEING OF CLOTHS, is the art of tingeing cloth, or other matter, with a permanent colour, by penetrating its substance, and imparting different colours to wool, silk, linen, &c. The substances employed are called colouring matters or dye-stuffs, and are extracted from animal and vegetable substances. If the colouring matters were merely spread over the surface of the fibres of cloth, the colours produced might be bright, but they could not be permanent; because the colouring matter would disappear whenever the cloth was washed or exposed to the weather. The colouring matter cannot seize upon the cloth permanently, unless there be an affinity between them. And since there can be no affinity till the dye-stuffs have been reduced to their integrant particles, dyeing is a process purely chemical. The colouring matter is first dissolved in some liquid which has a weaker affinity for it than the cloth has. When the cloth is dipped in this solution, the colouring matter is brought within the attracting distance; the cloth acts upon it, and, from its stronger affinity, takes it from the mordant and fixes it upon itself. The equality of the colour is also secured by this contrivance, as every part of the cloth has an opportunity of attracting to itself the proper proportion of colouring particles. Wool has the strongest affinity for almost all colouring matters; the next strongest is cotton, which has a considerably weaker affinity, and linen the weakest of all. In order therefore to dye cotton or linen, the dye-stuffs should be dissolved in a substance for which it has a weaker affinity than for the solvent employed in the dyeing of wool or silk. To dye wool, we use *oxyde of iron;* to dye cotton or linen, *acetous acids* answer best.

Of Mordants. To render dyeing colours permanent, a *mordant* is pitched upon, which has a powerful attachment to both the cloth and the colouring matter. The *mordant* is previously combined with the cloth, which is then plunged into the solution of dye-stuff, and the dye-stuff combines with the mordant, which being firmly combined with the cloth, secures the permanency of the dye. The proper preparation and the application of mordants are the principal considerations in the art of dyeing. The mordants must be previously dissolved in some liquid which has a weaker affinity for them than the cloth has to which they are to be applied; and the cloth, to saturate itself with the mordant, must be dipped or steeped in the solution. The mordants are *earths, metallic oxydes, tan,* and *oil.*

Alumine, the most important mordant earth that dyers use, is indispensable to dyers and calico printers, not only on account of its cleansing and opening the pores of the substances to be dyed, and thus rendering them fit to receive the colouring particles, but also from its more essential property of fixing the colours, or that they cannot afterwards be washed out. Alumine is used either in the state of common alum or in that of acetite of alumine.

Lime is also used as a mordant, either as lime water, or sulphate of lime dissolved in water.

The *metallic oxydes* of tin and iron are the most generally used; the former gives brightness to reds and scarlets, and precipitates the colouring matter in other dyes; the latter has a strong affinity for all kinds of cloth, as is proved abundantly by the difficulty we have to remove iron spots (moulds) from linen or cotton cloth. And as a mordant it is used either as sulphate of iron or acetite of iron.

Tan and Oil. On the leaves and buds of the oak certain excrescences are formed, in consequence of the puncture of insects, as a lodgment for their eggs and a habitation for their future young. These are termed *galls,* and if, when arrived at a certain state, they are infused in a weak solution of vitriol, they impart to it a purple or violet tinge; and after the whole colouring matter is extracted, this becomes perfectly black. Considerable quantities of galls are used in dyeing, and for other purposes. Tan adds to the weight of silk, and is therefore much used; oil is also used for the same purpose.

Besides these, *tartar, acetite of lead, common salt, sal ammoniac, sulphate* or *acetite of copper,* are used as mordants, which not only render the dye permanent, but have also considerable influence on the colour produced. The same colouring matter produces very different dyes, according as the mordant is changed. Suppose, for instance, that the colouring matter be cochineal; if we use the aluminous mordant, the cloth will acquire a crimson colour; but the oxyde of iron produces with it a black. In dyeing, then, it is not only necessary to procure a mordant which has a sufficiently strong affinity for the colouring matter and the cloth, and a colouring matter which possesses a wished for colour in perfection, but we must procure a mordant and a colouring matter of such a nature, that, when combined together, they shall possess the wished-for colour in perfection. It is evident too, that a great variety of colours may be produced with a single dye-stuff, provided we can change the mordant sufficiently. The colouring matter with which the cloth is dyed, does not cover every portion of its surface: its particles attach themselves to the cloth at certain distances from each other; for cloth may be dyed different shades of the same colour, lighter or darker, merely by varying the quantity of colouring matter. With a small quantity, the shade is light; and it becomes deeper as the quantity increases; now, this would be impossible, if the dye-stuff covered the whole of the cloth. That the particles of colouring matter, even when the shade is deep, are at some distance, is evident from this well-known fact, that cloth may be dyed two colours at the same time. All those colours to which the dyers give the name of *compound,* are in fact two different colours applied to the cloth at once. Thus cloth gets a *green* colour, by being first dyed *blue* and then *yellow.*

The colours denominated by dyers, *simple,* because they are the foundation of all their other processes, are four; namely, *blue, yellow, red,* and *black.* To these they usually add a fifth, under the name of *root,* or *brown* colour.

To dye Blue. The substances principally used in this dye, are indigo and woad, with which every kind of cloth may be dyed without a mordant. *Indigo* is brought from the West Indies. It is drawn from the leaves of a plant called *anil. Woad* is obtained from the leaves of a plant, which, when ripe, are gathered and suffered to lie some time, and then put under the wheel to be bruised or ground; after this they are laid eight or ten days in piles or heaps; and at last made up into balls, which are laid in the shade, on hurdles, to dry. The balls are then pulverized, spread upon the ground, and watered: it smokes and heats till it becomes dry; it is then fit for use. The ancient Britons dyed their bodies with this substance. Woad-blue is a very deep blue, almost black; and is the base of so many sorts of colours, that the dyers have a scale by which they compose the different casts, or degrees of woad.

Process. When *wool, cotton,* or *silk* is intended to be dyed, the cloth is first wetted with hot water and wrung out; then it is immersed in a clear dye-liquor, and remains therein according to the shade wished for; it comes out green, but soon turns blue on being exposed to the air. *Cotton* intended to be dyed blue is first passed through water containing sulphuric acid. Silk is dyed a light blue by a ferment of six parts of bran, six of indigo, six of potash, and one of madder. But cotton and linen are dyed blue by a solution of one part of indigo, one of green sulphate, and two parts of quick-lime.

Mr. Richard Badnall, of Leck, in Staffordshire, silk manufacturer, has taken out a patent for improvements in the application of Prussian blue to the purposes of dyeing silk, cotton, wool, or any other article; and, in the application of pressure to dyeing in general.

The Prussian blue being previously ground as fine as possible, is put into any convenient vessel of glass or earthenware. Strong muriatic acid is to be poured upon it a little at a time; and the mass is to be kept constantly stirred, with a rod of white wood, a piece of tobacco pipe, or any other material not liable to be acted upon by the acid. The stirring must be continued till the mixture has become a smooth homogeneous mass of a semi-gelatinous consistence. The proportion of acid requisite for this purpose depends, in some degree, on the quality of the Prussian blue, and, therefore, cannot be precisely set forth in words; but, by proceeding carefully, as above described, it is impossible to fall into error; as the mixture, if made too thin from excess of acid, may be rectified by the subsequent addition of more Prussian blue. This mixture may be used as soon as made; but it is better after three or four days, and its qualities are not altered by age. In dyeing silk with the Prussian blue, prepared as above, Mr. B. proceeds in the following manner:

"The gum having been discharged from the silk by any of the usual means, the silk is steeped, for three or four hours, in a cold solution of alum in water, of the common strength employed by silk dyers; and then rinsed in cold water.

"The dye vat is composed by diluting the prepared Prussian blue with cold water, till its colour is of the required depth, according to the particular tint intended to be given to the silk. The silk, prepared as above, is then to be put on sticks, and immersed in the bath, taking care that it be constantly turned, that the colour may be perfectly level, and that it remain in the bath till it has acquired the proper tint or shade. It is then to be well washed in running water till it ceases to be discoloured by it. Lastly, the silk is to be dried, either in the shade, or in a stove heated to not more than summer temperature.

"From Prussian blue, prepared as above, various greens and purples may be obtained; either by combining it with the ingredients usually employed for such colours, and dipping the silk in this compound bath; or, by using the bath of prepared Prussian blue, either before, or after the application of the other ingredients, according to circumstances, and to the nature of such ingredients. The proportion, however, it is not necessary to recite: the object of this part of the patent being merely by a new mode of preparing Prussian blue, to dye silk, cotton, wool, or any other article, either alone, or mixed and combined with other dyeing materials.

"The second invention is the application of pressure to dyeing in general, whether it be that of thick cloths, hats, woods for veneering, or any other purpose; or any other or more delicate materials, such as linen, cotton, or silk goods, lace, &c. For this purpose, the materials to be dyed are to be placed, with the dyeing liquor, in any suitable vessel of wood, copper, iron, or other material; the aperture of which vessel can be secured water-tight, by a lid fitted to it by any suitable and well-known means. To this vessel is to be fitted a hydrostatic pressure-pump, (as Bramah's, for example,) or any other machinery employed for the purpose of producing high pressure; such as a column of water or mercury of sufficient height, &c. All things being thus adjusted, the lid is to be fitted securely on, and the pump worked, until the necessary pressure is obtained; when it is evident, that if the goods are put in dry, or well wrung, the pressure thus produced will greatly facilitate the introduction of the dyeing liquor within the internal pores, particularly in heavy cloth goods, hats, woods, hard twisted silk, or lace; and, if necessary, suitable mechanical means may be employed to agitate and wring the goods while under pressure: but this is not claimed exclusively, but only the application of pressure to the forcing of the dyeing liquor into the pores of the cloths, hats, silk, woods, &c.; or the joint application of pressure, with suitable means for producing agitation, &c. &c."

To dye Red. The process of dyeing red requires a peculiar preparation of the stuffs, on the exactness of which the goodness and permanency of the colour depend. These preparatory ingredients consist of alum, tartar, nitric acid, or a solution of tin in nitric acid. Galls and alkaline salts are also sometimes added. The *Carthamus Tinctorius* plant, a native of Egypt and the Levant, gives a poppy, cherry and rose-red, and flesh colour to silk, and is also employed in making rouge. This last is made by precipitating with lemon juice the red colouring matter extracted by carbonate of soda. *Madder* is the root of a plant called *rubia tinctorium.* Alum and tartar are employed in the preparation of the ingredients for this red. *Cochineal* consists of an insect which is collected round the Indian fig-tree, and is found abundant in South America. Kermes, an insect about the size of a juniper berry, round, smooth, and glossy, is of a *beautiful red* colour, and full of a juice of the same dye. It is found adhering to the bark, on the stem and the branches of a small oak, growing in Spain, Languedoc, and other countries. This colour is the most permanent, but the least bright; it is apt also to be less spotted than the others: but, on account of the difficulty of procuring the insects which afford the colour, it is very seldom used in Britain. *Logwood* and *Brazil-wood* are also used for red dyes, but the colour is not durable. The latter grows in the warmest parts of South America. Logwood is found in the Bay of Campeachy. Alcohol best extracts the colouring matter of the logwood.

Of dyeing Yellow. The principal colouring matters for dyeing yellow are weld, fustic, and quercitron bark. Weld is a plant, which grows wild in barren and uncultivated places, particularly on coal-pit banks, in several parts of England. Fustic is the wood of a large tree which grows in the West Indies. Quercitron is a tree growing naturally in North America, the bark of which contains colouring matter. Yellow colouring matters have too weak an affinity for cloth, to produce permanent colours without the use of mordants. Cloth, therefore, before it be dyed yellow, is always prepared by combining some mordant or other with it, as alumine or oxyde of tin. Tan is often employed as a subsidiary to alumine, and in order to fix it more copiously on cotton and linen. Tartar is also used to brighten the colour; and muriate of soda, sulphate of lime, and even sulphate of iron, to render the shade deeper. The yellow dyed by means of fustic is more permanent, but not so beautiful as that by weld or quercitron. As it is permanent, and not much injured by acids, it is used in dyeing compound colours, where yellow is required. The mordant is alumine. When the mordant is oxyde of iron, fustic dyes a permanent drab colour. Weld and quercitron bark yield nearly the same colour; but as the bark yields colouring matter in much greater abundance, it is more convenient, and cheaper than weld. The method of using each of the dye-stuffs is nearly the same.

To dye Wool Yellow. Boil the wool for an hour with about one-sixth of its weight of alum, dissolved in water. Then plunge it, without being rinsed, into a bath of warm water, containing as much quercitron bark as equals the weight of the alum employed as a mordant. The cloth is now turned through the boiling liquid, till it has acquired the intended colour. Then a quantity of clean powdered chalk, equal to $\frac{1}{100}$ part of the weight of the cloth, is stirred in, and the operation of dyeing continued for eight or ten minutes longer. By this method a pretty deep and lively yellow may be given fully as permanent as weld yellow. For very bright orange yellow, it is necessary to have recourse to the oxyde of tin as a mordant; and to produce bright golden yellows, some alum must be added along with the tin. But to give the yellow a delicate green shade much admired, tartar must be added in different proportions, according to the shade. And by adding a small proportion of cochineal, the colour may be raised to a fine orange, or even an aurora.

Silk may be dyed different shades of yellow, either by weld or quercitron bark, but the last is the cheapest of the two. The proportion should be from one to two parts of bark to twelve parts of silk, according to the shade. The bark, tied up in a bag, should be put into the dyeing vessel, while the water which it contains is cold; and when it has acquired the heat of about 100 degrees, the silk, having been previously alumed, should be dipped in, and continued till it assumes the wished-for colour. When the shade is required to be deep, a little chalk or pearl-ash should be added towards the end of the operation.

Cotton and *Linen* are dyed yellow, thus: the mordant acetite of alumine is prepared by dissolving one part of acetite of lead, and three parts of alum, in a sufficient quantity of water. In this solution, heated to the temperature of 100 degrees, the cloth is soaked for two hours, then wrung out and dried. The soaking may be repeated, and the cloth again dried as before. It is then to be barely wetted with lime water, and afterwards dried. The soaking in the acetite of alumine may be again repeated, and if the shade of yellow is required to be very bright and durable, the alternate wetting with lime water and soaking in the mordant may be repeated three or four times. By this contrivance, a sufficient quantity of alumine is combined with the cloth, and the combination is rendered permanent by the addition of lime. The dyeing bath is prepared by putting 12 or 18 parts of quercitron bark (according to the depth of the shade required) tied up in a bag, into a sufficient quantity of cold water. Into this bath the cloth is put, and turned round in it for an hour, while its temperature is gradually raised to 120 degrees; it must be then brought to a boiling heat, and after that, the cloth allowed to remain in it only a few minutes. If it be kept long at a boiling heat, the yellow acquires a brown shade. Nankeen yellow is obtained by a solution of the red sulphate of iron, which is combined with the cloth by carbonate of potash.

To dye Fawn Colour. The process of dyeing this colour differs from others, the wool merely requiring a simple immersion in water. Various substances are used for dyeing brown or fawn colour. 1. The bark or rind of the *walnut-tree.* Its shades are uncommonly fine; its colours solid; and it renders the wool flexible and soft. A cauldron half full of water is placed over the fire; as soon as it grows warm, bark is added in proportion to the quantity of stuffs intended to be dyed, and the lightness or depth of the shades required. It is then boiled for a quarter of an hour, when the cloths, previously moistened with warm water, are immersed, frequently turned, and well stirred, till they have sufficiently imbibed the colour. They are then dried and dressed in the usual manner. The *root* of the walnut-tree is also employed, but with a different process. When the green *walnut-shells* are used, they are collected when the nuts are ripe; and are put into casks, which are afterwards filled with water, and thus preserved till the succeeding year. The bark of the *alder-tree* is chiefly used for worsted, imparting shades darkened with copperas. It is also used for wool that is not required to be very dark, as it equally withstands the effects of the sun and rain. *Sanders-wood* is much inferior to walnut-shells; stiffens, and consequently injures the wool. It is in general mixed with galls, sumach, and alder-bark, without which its colour could not be extracted. *Sumach,* where dark colours are required, is frequently substituted for nut-galls, in which case a greater proportion becomes necessary. These different substances, however, are not unfrequently mixed together; they are of a similar nature, differing only in a degree of colour, and it is easy to obtain various shades. It is both solid and permanent. *Soot* is only used when the other ingredients cannot be procured. It is not only less solid than the others, but also hardens, and imparts a very disagreeable smell to the wool or stuff.

To dye Cloth Black. Red oxyde of iron and tan are employed; log is used as an auxiliary, because it communicates lustre, and adds to the fulness of the black. *Cloth*, before it receives a black colour, is dyed blue; but if the cloth be coarse, the blue dye is expensive; in that case walnut-peels are used to give it a brown colour. *Wool* is boiled for two hours in a decoction of nut-galls, then kept two hours more in a bath of logwood and sulphate of iron, at a scalding heat, but not boiled. It must be frequently exposed to the air during the process, to imbibe oxygen before the cloth can acquire a proper colour. *Silk* is dyed nearly in the same manner, but as it is capable of combining with a great deal of tan, the quantity given is varied at the pleasure of the artist, by allowing the silk to remain a longer or shorter time in the decoction. *Linen* and *Cotton* previously dyed blue, are steeped for twenty-four hours in a decoction of nut-galls, mixed with a decoction of alder-bark. A bath is prepared, containing an acetite of iron. Into this bath the cloth is put in small quantities at a time, wrought with the hand for a quarter of an hour, wrung out, and aired again; then wrought in a fresh quantity of the bath, and afterwards aired. These processes are repeated till the requisite colour has been given to the cloth.

Of dyeing Compound Colours, which are produced by mixing two simple colours together; or, by dyeing cloth first one simple colour, and then another. These colours vary to infinity, according to the proportions of the ingredients employed, and may be arranged under the following classes. Mixtures of, 1. Blue and yellow. 2. Blue and red. 3. Yellow and red. 4. Black and other colours.

Mixtures of *blue* and *yellow* form *green*, which is distinguished by dyers into a variety of shades, according to the depth of the shade, or the prevalence of either of the component parts. Thus we have *sea-green, grass-green, pea-green*, &c. Wool, silk, and linen, are usually dyed green, by giving them first a blue colour, and afterwards dyeing them yellow; because, when the yellow is first given, several inconveniences follow: the yellow partly separates again in the blue vat, and communicates a green colour to it, and thus renders it useless for every other purpose, except dyeing green. Any of the usual processes for dyeing blue and yellow may be followed, taking care to proportion the depth of the shades to that of the green required. When sulphate of indigo is employed, it is usual to mix all the ingredients together, and to dye the cloth at once; this produces what is known by the name of *Saxon* or *English green*.

Mixtures of *blue* and *red* form different shades of *violet, purple*, and *lilac*. Wool is generally first dyed blue, and afterwards scarlet, in the usual manner. If cochineal be mixed with sulphate of indigo, the process may be performed at once. Silk is first dyed crimson by means of cochineal, and then dipped into the indigo vat. Cotton and linen are first dyed blue, then galled, and soaked in a decoction of logwood; but a more permanent colour is given by the oxyde of iron.

Mixtures of *yellow* and *red* produce *orange*. When blue is combined with red and yellow on cloth, the resulting colour is *olive*. Wool may be dyed orange, by first dyeing it scarlet, and then yellow. When it is dyed first with madder, the result is *cinnamon colour*. Silk is dyed orange by means of carthamus; a cinnamon colour by logwood, Brazil-wood, and fustic mixed together. Cotton and linen receive a cinnamon colour by means of weld and madder; and an olive colour, by being passed through a blue, yellow, and then a madder bath.

Mixtures of *black* with other *colours*, constitute *grays, drabs*, and *browns*. If cloth be previously combined with brown oxyde of iron, and afterwards dyed yellow with quercitron bark, the result will be a *drab* of different shades, according to the proportion of mordant employed. When the proportion is small, the colour inclines to olive or yellow; on the contrary, the drab may be deepened or saddened, as the dyers term it, by mixing a little sumach with the bark.

DYKES. That the surface of the earth has been fractured since its consolidation, is proved by the appearances which rocks and strata in many situations present. It is further proved by the existence of vertical seams intersecting them, and filled with mineral matter of a different kind. When the substance found in these vertical seams is stone or earth, and they are of considerable thickness, they are called *dykes* or *faults*. When filled with metallic ores, they are generally called *veins*.

DYNAMICS, is the science of moving powers, or of the action of forces on solid bodies, when the result of that action is motion. Mechanics, in its most extensive meaning, is the science which treats of quantity, of extension, and of motion. Now that branch of it which considers the state of solids at rest, such as their equilibrium, their weight, pressure, &c. is called *Statics*; and that which treats of their motion, *Dynamics*. So when fluids, instead of solids, are the subjects of investigation, that branch which treats of their equilibrium, pressure, &c. is called *Hydrostatics*, and that which treats of their motion, *Hydrodynamics*.

DYSENTERY, in Medicine, a flux or flatulency of the bowels, occasioned by stoppage of perspiration, especially in hot weather, unwholesome food, damp clothes, &c. The most proper treatment is by taking a gentle vomit, followed by rhubarb, or ten drachms of Glauber's salts.

DYSPEPSY, a difficulty of digestion, for which physicians prescribe bitters.

DYSPNŒA, a difficulty of breathing, usually called asthma.

DYTISCUS, *the Water Beetle*, in Zöology, a genus of insects of the order coleoptera, of which there are 23 species.

E.

E, the fifth letter in the alphabet, as a numeral, stands for 250. In Music, it denotes the tone *e-la-mi*. In the Calendar, it is the fifth of the dominical letters. And in Sea-charts, it distinguishes all the easterly points.

EAR, Auris, in Anatomy, the organ of hearing.

EARINGS, are certain small ropes employed to fasten the upper corners of a sail to its respective yard, for which purpose one end of the earing is spliced to the cringle fixed in that part of the sail, and the other end is passed five or six times round the yard-arm and through the cringle; the two first turns, which are intended to stretch the head of the sail tight along the yard, are passed beyond the lift and rigging on the yard-arm, and are called outer turns, while the rest which draw it close up to the yard, and are passed within the lift, &c. are called inner turns. N. B. Every reef on a yard has its respective earings, which are passed in the same manner.

EARL, a British title of nobility, next below a marquis, and above a viscount. Earls were anciently called *comites*, because they were wont to wait upon the king for counsel and advice. The Germans call them *graves*, as landgrave, margrave, palsgrave, rheingrave; the Saxons, ealdermen; the Danes, eorlas; and the English, earls. The title, originally, died with the man. William the Conqueror first made it hereditary, giving it in fee to his nobles, and allotting them for the support of their state the third penny out of the sheriff's court, issuing out of all pleas of the shire whence they had their title.

EARL Marshal of England, a great officer who had anciently several courts under his jurisdiction, as the court of chivalry and the court of honour. Under him is also the herald's office, or college of arms. He has some pre-eminence in the court of Marshalsea, where he may sit in judgment against those who offend within the verge of the king's court.

EARNEST, a part of the price paid in advance to bind parties to the performance of a verbal agreement. The party is then obliged to abide by his bargain, and is not discharged upon forfeiting his earnest, but may be sued for the whole money stipulated, and damages; no contract for sale of goods not to be delivered immediately, to the value of £10 or more, is valid, unless contract is made by the parties, or those lawfully authorized by them, or earnest is given.

EARTH, in Astronomy and Geography, one of the primary planets, being this terraqueous globe which we inhabit. *See* Astronomy.

EARTHQUAKE, a tremor or shaking of the earth, frequently accompanied with dreadful noises underground, or in the atmosphere, often destroying towns and cities, throwing down rocks, levelling hills, changing the course of rivers, &c. The most remarkable earthquakes recorded in history are, that of Herculaneum, by which that city was wholly destroyed, a. d. 79. The destruction of Nicomedia, Cæsarea, and Mica, in Bithynia, a. d. 126. A dreadful one in Syria, by which about five hundred cities were destroyed or damaged in 745. Catania, in Sicily, destroyed, and 15,000 perished in the ruins, 1173. Port Royal, in Jamaica, with 3000 inhabitants, overwhelmed in 1692. Messina, in Sicily, destroyed, and above 18,000 persons killed, 1693. Lima and Callao, in South America, destroyed, and 20,000 persons, 1746. A dreadful one at Lisbon, in which above 10,000 of the inhabitants perished, 1755. This earthquake extended to Spain, Morocco, Constantinople, France, and England. The year 1783 was rendered remarkable by the destruction of the two Calabrias and part of Sicily; but this was only the beginning of a succession of fatal earthquakes, which continued to spread desolation over that part of the world for the space of two years.—The list of these awful visitations of Providence might be easily enlarged, but we shall close the enumeration by mentioning two of recent occurrence:—*viz.* the dreadful earthquake of the Caraccas, in South America, in 1812, by which several cities and towns were ruined, or greatly injured, and many thousands of their inhabitants destroyed;—and that of Aleppo, Antioch, and the surrounding country, in 1822, by which 20,000 persons perished, and as many were maimed and wounded.

EARTHS. The stony or pulverulent masses, which are the chief component parts of the mountains, valleys, and plains of our globe, consist of a few substances called earths, as barytes, strontites, lime, silica, magnesia, alumina or clay, glucine, zirconia, yttria, and thorina. They are incombustible but very little soluble in water or alcohol; have little or no taste; their specific gravity less than most of the metals; when pure, they assume the form of a white powder; infusible, capable of combining with the acids, insipid to the taste, disposed to unite with the alkalies, sulphur, or phosphorus, and each other, either by fusion or solution in water. The class of earths will always be of important consideration with mankind. It is not unlikely that hereafter the other earths may be decomposed, and found to be oxides in like manner.

Earths, in Chemistry, are all those stones which we tread under foot, but which consist of a few elementary principles. These earths are silex, alumine, magnesia, glucine, yttria, and zircon, which, when freed from foreign matters, are generally of a white colour, insoluble in water, incombustible, and not four times the specific gravity of water.

Silex, or *Siliceous Earth*, is the basis of all substances known by the name of quartz and silex. It has never been found pure in a state of nature, but in combination with other substances, it abounds in almost every country of the globe. Common flint contains ninety-seven parts out of a hundred of silex, it consequently has given its name to this earth, silex being the Latin word for flint. When purified it is a white powder, the particles of which are harsh to the touch, as if they consisted of very minute grains of sand. It is not quite three times as heavy as water, and has neither taste nor smell. Water will not dissolve it, nor any kind of acid, except fluoric. Sir H. Davy has discovered it to have a metallic basis, to which he has given the name of *silicium*. Silex has various uses in the arts, and is one of the most valuable substances we are acquainted with. In various states of combination it is employed in the making of roads, as an ingredient in glass, for making chemical furnaces and utensils, in the manufacture of pastes or artificial gems, and for innumerable other useful purposes.

Alumine, is a kind of earth, so called from its forming the basis of alum. It is very soft, compact, and tenacious, about twice the weight of water, and when breathed upon, has a smell which is peculiar to all clayey productions. In the fire it shrinks, and becomes so hard as even to strike fire with steel. It readily absorbs water, and is dissolved by most acids. Some writers state, that pure alumine has been discovered in a native state near Halle, in Germany. It is found in a crystallized form, and nearly in a state of purity, in the Oriental ruby and sapphire. From the different combinations of alumine are made all kinds of earthenware. To the dyer and the calico-printer it is an article of indispensable necessity; and fullers and scourers of cloth employ it with great advantage in their respective operations.

Zircon, when freed from those substances with which it is combined, is a white and somewhat rough powder, insipid to the taste, insoluble in water, and about four times as heavy as that fluid. It is found in the two kinds of precious stone called jargoon and hyacinth, and has not hitherto been applied to any useful purpose.

Glucine, is a kind of earth of peculiar nature which is found in the emerald and beryl, and when purified forms a soft, light, and white powder, without smell, and of a sweetish taste. To the last of these qualities it is indebted for its name, which is derived from a Greek word signifying sweet. It is somewhat unctuous to the touch, and about three times as heavy as water. The uses of this earth, whatever they may be, are not known.

Yttria, is an earth which, amongst other particulars, differs from glucine by its weight, since it is nearly five times heavier than water. In a natural state it occurs as the basis of a black Swedish mineral, called gadolinite. When cleansed by chemical process from all its impurities, it is a fine, white, and inodorous powder.

Barytes, is a white, porous, and very heavy earth, which can only be obtained pure by chemical process. It is easily reduced to powder, and is soluble in all kinds of acids. To the taste it is very harsh and caustic, and if taken into the stomach proves an extremely virulent poison. In some respects it agrees with the alkalies, particularly in its property of changing blue vegetable colours to green, and in corroding like them, though with less energy, all kinds of animal substances. From these circumstances it has sometimes been denominated an alkaline earth. Saturated with sulphuric and carbonic acid, it constitutes the minerals denominated sulphate and carbonate of barytes. It has been discovered to have a metallic base, which is called *barium*.

Strontian, is an earth which, like barytes, is not found otherwise than in combination with sulphuric and carbonic acids. It occurs in great abundance in different parts of the world, and when purified, forms a porous mass, of grayish white colour, acrid taste, and somewhat alkaline nature. This earth converts vegetable blue colours to green, but does not act so strongly on animal bodies as barytes, nor is it poisonous like that substance.

Lime, the basis of all those substances which are denominated *calcareous*, is only to be obtained in a state of purity by artificial process. Combined with carbonic acid, it forms limestone, chalk, and marble; but correctly speaking, none of these substances are lime, though they are all capable of being converted into such by burning. Lime may also be obtained from oyster and other sea shells. When pure, it is of a white colour, and moderately hard substance, though easily reducible to powder. Its taste is burning and acrid, and, like the alkalies, it changes vegetable blue colours to green. It has likewise the property of corroding and destroying animal substances. Lime, when pure, absorbs water with great avidity, becomes hot, and falls into powder. Even merely exposed to the open air, it gradually attracts moisture, and assumes a powdery form; soon after which it becomes saturated with carbonic acid from the atmosphere, and is thereby again converted into carbonate of lime. It occurs abundantly in almost every country, but always in combination with some acid,—carbonic, sulphuric, boracic, fluoric, or phosphate. This substance has a metallic basis, which has been denominated *calcium*. The particular uses of lime will be hereafter detailed.

Magnesia, is a light and perfectly white kind of earth, of soft powdery appearance, without taste or smell, and somewhat more than twice as heavy as water. It is not found in this pure state in nature, but may be prepared from Epsom salt, which consists of magnesia in union with sulphuric acid. The slightly acrid taste observable in the magnesia used in medicine, arises from a portion of lime which it contains. This substance does not dissolve in water, but is soluble in every kind of acid. It has the property of changing delicate blue colours to green.

EASE THE SHIP, the command given to the steersman to put the helm close to the lee-side, or, in the sea phrase, hard-a-lee, when the ship is expected to pitch or plunge her fore part deep in the water, while close-hauled. The reason usually given for this practice is, that the sudden movement of the helm prevents the ship's head from falling with so much weight and rapidity into the hollow of the sea, as it would otherwise do; which is presuming, that the slow and uncertain effect of the helm is sufficient to retard the certain and violent action of gravity, a position that necessarily infers a very singular theory of mechanics. We shall not endeavour to advance any argument in favour of this practice, only to remark, that it is most religiously observed both in merchant ships and his majesty's navy.

EASTER, a Festival of the Christian church, observed in memory of our Saviour's resurrection. The Asiatic churches kept their Easter on the same days the Jews observed their passover; and others, on the first Sunday after the first full moon in the new year. This controversy was determined in the council of Nice, when it was ordained, that Easter should be kept on one and the same day, which should always be a Sunday. But though the Christian churches differed as to the time of celebrating Easter, all agreed in shewing particular respect to this festival.

EAU-DE-LUCE, a volatile preparation, thus made: ten or twelve grains of white soap are dissolved in four ounces of rectified spirit of wine, after which the solution is strained, and a drachm of rectified oil of amber is added, and the whole is filtrated. Afterwards some strong volatile spirit of sal ammonia should be mixed with the solution.

EAVES, in Architecture, the margin or edge of the roof of a house, being the lowest tiles, slates, or thatch, that hang over the walls, to throw off the water at some six or nine inches from the wall.

EBB, the reflux of the tide, or the return of it back from the highest of the flood, usually termed full sea, or high water.

EBENUS, *the Ebony Tree*, a genus of the decandria order, in the diadelphia class of plants, and in the natural method ranking under the 32d order, papilionaceæ. There are two species. 1. The cretica, a native of Crete and other islands in the Archipelago, rises with a shrubby stalk three or four feet high, which puts out several side branches with hoary leaves at each joint, composed of five narrow spear-shaped lobes, which join at their tails to the foot-stalk, and spread like the fingers of a hand. The branches are terminated by spikes of purple flowers. 2. The pinnata, a biennial, and also a native of the Levant, constitutes the genus ebenus of botanists; but that which is called *ebony wood*, and which is brought from the Indies, is hard and heavy, susceptible of a fine polish, and on that account is used in inlaid works, &c.; the most usual ebonies are black, red, and green, which come from Madagascar and the island of St. Maurice. Black ebony, preferred to the others, is now much less used than formerly, since the discovery of so many ways of giving other hard woods a black colour. The green ebony, besides Madagascar and St. Maurice, grows in the Isle of Tobago. Of red ebony, called also grenadilla, we know little more than the name. Cabinet-makers, in-layers, &c. make pear tree and other woods pass for ebony, by giving them a black colour with a strong decoction of galls, to which is added a small quantity of vitriolated iron.

EBULLITION, the act of boiling up with heat, when a fluid, as water, is passing off from a state of fluidity to that of an uniform gas, in consequence of the application of heat, which converts the water into vapour or steam.

ECCENTRIC, in Geometry, denotes two circles, or spheres, which, though contained in some measure within each other, yet have not the same centre; and is thus opposed to concentric, which indicates that two figures have a common centre. In Astronomy, the *eccentric* place of a planet is its place as seen from the sun, and which, when referred to the ecliptic, coincides with the heliocentric longitude. And the *eccentricity* of a planet is the distance between the centre and focus of the ellipsis in which it revolves.

ECCLESIASTICAL COURTS, as the *Archdeacon's*, the *Consistory*, the court of *Arches*, the *Peculiar's*, the *Prerogative*, and the court of *Delegates*.

ECHENEIS, *the Remora*, in Ichthyology, a genus belonging to the order of thoracici, of which there are two species. 1. The remora, or sucking-fish. 2. The neucrates; both natives of the Indian ocean. They were often found adhering so strongly to the sides of sharks and other great fish, as to be got off with difficulty.

ECHINUS, in Zöology, the sea hedge-hog, a genus of insects belonging to the order of vermes mollusca.

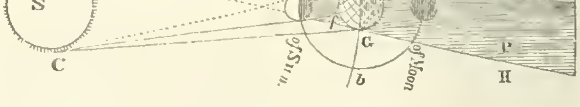
ECHO, a sound reflected, or reverberated from a solid concave body, and thence repeated to the ear. *See* ACOUSTICS.

ECLECTICS, ancient Philosophers, who, without attaching themselves to any particular sect, selected whatever appeared to them the best and most rational from each.

ECLIPSE OF THE SUN, is an occultation of part of the face of the sun, occasioned by an interposition of the moon between the earth and the sun, consequently all eclipses of the sun happen at the time of new moon.

ECLIPSE *of the Moon*, is a privation of the light hf the moon, occasioned by an interposition of the earth between the sun and the moon, consequently all eclipses of the moon happen at full moon; for it is only when the moon is in opposition, that it can come within the shadow of the earth, which must always be on that side of the earth which is from the sun. The earth being in the plane of the ecliptic, the centre of its shadow is always in that plane; if therefore the moon be in its nodes, that is, in the plane of the ecliptic, the shadow of the earth will fall upon it; also, since this shadow is of considerable breadth, it is partly above and partly below the plane of the ecliptic; if therefore the moon in opposition be so near one of its nodes, that its latitude is less than half the breadth of the shadow, it will be eclipsed. But, because the plane of the moon's orbit makes an angle of more than five degrees with the plane of the ecliptic, it will frequently have too much latitude at its opposition to come within the shadow of the earth.

Now let S represent the sun, as in the figure, *m* the moon between the earth and the sun, *a* E G *b* a portion of the earth's orbit, *e* and *f* two places on the surface of the earth The dark part of the moon's shadow is called the *umbra*, and the light part the *penumbra*; and it is evident, that if a spectator be situated on that part of the earth where the *umbra* falls, that is between *e* and *f*, there will be a total eclipse of the sun at that place; at *e* and *f*, in the penumbra, there will be a *partial* eclipse, and beyond the penumbra there will be no eclipse. As the earth is not always at the same distance from the moon, if an eclipse should happen when the earth is so far from the moon that the lines F *e* and C *f* cross each other before they come to the earth, a spectator situated on the earth, in a direct



line between the centres of the sun and moon, would see a ring of light round the dark body of the moon, called an *annular* eclipse; when this happens, there can be no total eclipse any where, because the moon's umbra does not reach the earth. People situated in the penumbra will perceive a partial eclipse; and an eclipse can never be annular longer than 12 minutes 24 seconds, nor total longer than 7 minutes 58 seconds, nor can the duration of an eclipse of the sun ever exceed two hours.

The sun being larger than the earth, the shadow of the earth is a cone, the base of which is on the surface of the earth, and the moon is eclipsed by a section of the earth's shadow. If the earth were larger than, or equal to, the sun, its shadow would either perpetually enlarge, or be always of the same dimension; but in this case the superior planets would sometimes come within it, and be eclipsed, which never happens. Therefore, the sun is larger than the earth, and produces a shadow from the earth of a conical form, which does not extend to the orbit of Mars.

An eclipse of the moon is *partial*, when only a part of its disc is within the shadow of the earth; it is *total*, when all its disc is within the shadow; and it is *central*, when the centre of the earth's shadow falls upon the centre of the moon's disc. Let S represent the sun, E G the earth, and *m* the moon in the earth's umbra, having the earth between her and the sun; D E P and H G P the penumbra. Now, the nearer any part of the penumbra is to the umbra, the less light it receives from the sun, as is evident from the figure; and as the moon enters the penumbra before she enters the umbra, she gradually loses her light and appears less brilliant. The duration of an eclipse of the moon, from her first touching the earth's penumbra to her leaving it, does not exceed five hours and a half. The moon does not continue in the earth's umbra longer than three hours and three-quarters, in any eclipse, neither is she totally eclipsed for a longer period than one hour and three-quarters. As the moon is actually deprived of her light during an eclipse, every inhabitant upon the face of the earth who sees the moon, sees the eclipse.

An eclipse of the sun, as we have said, happens when the moon, passing between the sun and the earth, intercepts the sun's light, and the sun can only be eclipsed at the new moon, or when the moon, at its conjunction, is in or near one of its nodes. For unless the moon is in or near one of its nodes, it cannot appear in or near the same plane with the sun; without which it cannot appear to us to pass over the disc of the sun. At every other part of its orbit, it will have so much northern or southern latitude, as to appear above or below the sun. If the moon be *in* one of its nodes, having no altitude, it will cover the whole disc of the sun, and produce a *total eclipse*, except when its apparent diameter is less than that of the sun; if it be *near* one of its nodes, having a small degree of latitude, it will only pass over a part of the sun's disc, or produce a partial eclipse.

In a total eclipse of the sun, the shadow of the moon falls upon that part of the earth where the eclipse is seen, and therefore a spectator, placed any where in the centre, will not see any part of the sun, because the moon will intercept all the rays of light coming directly from the sun; and it is manifest, that in this situation the moon, being an opaque body, will cast its shadow upon the part of the earth where the eclipse is total. In a partial eclipse of the sun, a *penumbra*, or imperfect shadow of the moon, falls upon that part of the earth where the partial eclipse is seen.

If the moon, when new, is in one of its nodes, the eclipse of the sun will be central. For then the centres of the earth, sun, and moon, being all in the plane of the ecliptic, and being now concentric, the centre of the moon will pass between the sun's centre and that of the earth. The penumbra of the moon, in a central eclipse, will not cover the whole disc of the earth; for the semidiameter of the moon's penumbra being equal to the sum of the apparent semidiameters of the sun and moon, about 16'. 23". × 15'. 37". or 32'. at the medium, its diameter is about 64'. whereas the diameter of the earth's disc is about 120'. whence the penumbra cannot cover the whole disc. The height of the shadow of the moon is about 60½ semidiameters of the earth. The semiangles of the earth's shadow and of the moon's shadow, being each equal to the sun's apparent semidiameter, the angles are equal to one another, and these cones are similar. Therefore, as the semidiameter of the base of the earth's shadow, (that is, of the earth,) is to the semidiameter of the base of the moon's shadow, (that is, of the moon,) so is the height of the earth's shadow to the height of the moon's shadow. Now the semidiameter of the earth is to that of the moon nearly as 100 to 28, and the height of the earth's shadow is about 217 semidiameters of the earth; whence the height of the moon's shadow is equal to about 60½ semidiameters of the earth; for 100 : 23 : : 217 60½ nearly.

An eclipse of the sun is said to be *annular*, when at the time of the eclipse a ring of the sun appears round the edges of the moon; and a central eclipse of the sun will be an annular one, if the distance of the moon from the earth at the time of the eclipse be greater than its mean distance. Were the orbit of the earth and that of the moon both in the same plane, there would be an eclipse of the sun every new moon, and an eclipse of the moon every full moon. But the orbit of the moon makes an angle of five degrees and a quarter with the plane of the earth's orbit, and crosses it in two points called the nodes. Astronomers have calculated, that if the moon be less than 17° 21' from either node, at the time of new moon, the sun may be eclipsed; or if less than 11° 34' from either node, at the full moon, the moon may be eclipsed; at all other times there can be no eclipse, for the shadow of the moon will fall either above or below the earth at the time of new moon; and the shadow of the earth will fall either above or below the moon, at the time of full moon. To illustrate this, suppose the right hand part of the moon's orbit, as in the figure, to be elevated above the plane of the paper, or earth's orbit, it is evident that the earth's shadow, at full moon, would fall below the moon: the left hand part of the moon's orbit at the same time would be depressed below the plane of the paper, and the shadow of the moon, at the time of new moon, would fall below the earth. In this case, the moon's nodes would be between E and *a*, and between G and *b*, and there would be no eclipse, either at the full or new moon; but, if the part of the moon's orbit between G and *b* be elevated above the plane of the paper, or earth's orbit, the part between E and *a* will be depressed, the line of the moon's nodes will then pass through the centre of the earth and that of the moon, and an eclipse will ensue.

An eclipse of the sun begins on the western side of his disc, and ends on the eastern; and an eclipse of the moon begins on the eastern side of her disc, and ends on the western. The average number of eclipses in a year is *four*, two of the sun, and two of the moon; and, as the sun and moon are as long below the horizon of any *particular place* as they are above it, the average number of visible eclipses in a year is two, one of the sun and one of the moon.

ECLIPTIC, in Astronomy, is a great circle in which the sun makes his apparent annual progress among the fixed stars. It is the real path of the earth round the sun. The intersection at 23° 28' is called the equinoctial points; the ecliptic is situated in the middle of the zodiac. The apparent path of the sun is either in the equinoctial, or in lines nearly parallel to it, and his apparent annual path may be traced in the heavens, by observing what particular constellation in the zodiac is on the meridian at midnight; the opposite constellation will shew, very nearly, the sun's place at noon on the same day.

EDDY, the water that by some interruption in its course runs contrary to the direction of the tide or current, and appears like the motion of a whirlpool.

EDGINGS, among Gardeners, the series of small but durable plants, set round the edges or borders of flower-beds, &c. The best and most durable plant for this use is box, which, if well planted and rightly managed, will continue in strength and beauty many years. The seasons for planting these are the autumn, and very early in the spring; and the best species for this purpose, is the dwarf Dutch box.

EDICT, an order or instrument signed and sealed by a prince, to serve as a law to his subjects. We find frequent mention of the edicts of the Prætor, the ordinances of that officer, in the Roman law. Edicts can have no room in Britain, because laws originate in the parliament, and not in the king.

EDITOR, the person who revises or prepares any work for publication.

EFFECT, the result or consequence of the application of a cause or agent, on some subject. It is an axiom in philosophy, that effects are proportional to their adequate causes.

EFFECTION, denotes the geometrical construction of a proposition; it is also used in reference to problems, which when they are deducible from, or founded upon, some general propositions, are called the *geometrical effections* of them.

EFFERVESCENCE, a small degree of ebullition: the agitation produced by the mixture of an acid and an alkali.

EFFICIENT CAUSE, that which produces an effect.

EFFLORESCENCE, the effect which takes place when bodies spontaneously become converted into a dry powder. It is almost always occasioned by the loss of the water of crystallization in saline bodies. Natron is an example of efflorescence, when it appears as a salt on the surface of the ground. Alum effloresces in the same way.

EFFLUVIUM, in Physiology, the minute particles which exhale from most, if not from all bodies in nature; a sort of invisible vapour, sensible only by its effect on the organ of smelling. Effluvia however in some cases become visible, constituting that which in animals and plants makes the matter of perspiration.

EFFORT, a term frequently used by mathematicians and philosophers, to denote the force by which a body in motion tends to produce an effect, whether the effect be really produced, or impeded by any obstacle which intervenes.

EGGS. The eggs of hens, and of birds in general, are composed of several distinct substances. 1. The shell, or external coating, which is composed of carbonate of lime ·72, phosphate of lime ·02, gelatine ·03. The remaining ·23 are perhaps water. 2. A thin, white, and strong membrane, possessing the usual characters of animal substances. 3. The white of the egg, for which *see* ALBUMEN. 4. The yolk, which consists of an oil, united with a portion of serous matter, sufficient to render it diffusible in cold water, in the form of an emulsion, and concrescible by heat. Yolk of egg is used as the medium for rendering resins and oils diffusible in water.

Preservation of Eggs for many Years.—Dip them in a solution of gum arabic in water, and imbed them in powdered charcoal. Charcoal being a non-conductor of heat, a uniform temperature will be preserved when moved from one climate to another. The method of preserving eggs by dipping them in boiling water, which destroys the living principle, is too well known to need further notice.

EIGHT, a number consisting of twice four. EIGHTH, an ordinal number, the next after the seventh.

EJECTMENT, in Law, is a mixed action, by which a lessee for years, when ousted, may recover his term and damages; it is real as to the lands, but personal as to the damages.

ELAIS, a genus of plants belonging to the natural order of palmæ. There is one species, from the fruit of which, resembling an olive in shape, the negroes extract the palm oil.

ELASTIC, that power which a body has of returning to the form from which it has been distorted. Thus the branch of a tree, the blade of a sword, &c. are said to be elastic, because if they are bent to a certain degree and then let go, they will of themselves return to their original form. Hence *Elastic Bodies* are such as admit of having their form altered by the application of a force or pressure, on the removal of which they will recover their original form or figure. In this respect all bodies which come within our knowledge, are comprehended under one of these three distinctions. If two bodies, when pressed together, suffer an alteration in their form, and if afterwards, on removing that pressure, they recover their original figures, they are called *elastic*. If, when pressed, their forms are not in the least altered, they are called *hard*. And if, when being pressed as above, they alter their forms, and retain the same after the pressure is discontinued, they are called *soft*. And both these last kind of bodies are termed *non-elastic*. We know, however, of no bodies that are *perfectly hard*, *soft*, or *elastic*, but all partake of these properties in a greater or less degree. Water was for a long time supposed to be incompressible, and perfectly *non-elastic*, but experiment shews, that this supposition was erroneous; and air, which is the most elastic fluid we know of, is now known not to possess this property in a perfect degree.

The principal Phenomena observable in Elastic Bodies.—1. A *perfectly* elastic body has a tendency to restore itself with the same force with which it is pressed or bent. 2. An elastic body exerts its force equally on all sides, but the effect is found principally where there is the least resistance. 3. Elastic bodies, in whatever manner they are struck or bent, are reflected, and rebound with the same force in an opposite direction; thus an elastic body will rebound from the plane on which it impinges, with the same velocity with which it meets it, and so as to make the angle of reflection equal to the angle of incidence. 4. A perfectly fluid body (being defined, that which cannot be compressed,) cannot be elastic. 5. A perfectly solid body cannot be elastic. 6. The elasticity of most bodies, particularly of long and slender forms, may be easily shewn, and even in very hard and compact bodies their elasticity may be manifested in various ways; thus, for instance, let a marble slab, or a flat and smooth iron, be covered with black lead, or with printing ink; then drop an ivory ball upon it from different heights, and the degree of compression on it will be indicated by the magnitude of the spot which will be found upon the ivory ball.

ELASTIC *Curve*, is the name that James Bernoulli gave to the curve which is formed by an elastic blade, fixed horizontally by one of its extremities in a vertical plane, and loaded at the other extremity with a weight, which by its gravity bends the blade into a curve, the determination of which involves investigations of the most intricate order. This curve is the same which a perfectly flexible right line would form itself into when supported at its two extremities, and loaded with an uniform fluid which fills the whole cavity of the curve, and is therefore not the same as the catenary, though frequently confounded with that curve.

ELASTIC *Fluids*, are those which are possessed of an elastic property, as air, steam, &c.

ELASTIC *Gum*, the same as caoutchouc, or Indian rubber.

ELASTICITY, is that property of bodies by which they restore themselves to their original figure after compression. Various hypotheses have been advanced by philosophers to account for this important property, some attributing it to one cause, and some to another; it is, however, now more generally supposed to arise from the presence of caloric, and the attractive and repulsive powers that have place between the minute particles which constitute a body, whether it be a solid or fluid.

ELATINE. A vegetable principle lately discovered in the juice of the seeds of the momordica elaterium, or cucumber. It is most violently purgative.

ELBOW *in the Hawse*, is when a ship, being moored in a tideway, swings twice the wrong way, thereby causing the cables to take half a round turn on each other.

ELDERS, among the Jews, persons of great age, experience, and wisdom. Elders, in the Presbyterian discipline, are officers who, with the ministers and deacons, compose the sessions of the kirk. The elders' business is to assist the minister in visiting the congregation upon occasion, to watch over the morals of the people of his district, and to give them private reproof in case of any disorder; but if the scandal be gross, or the person obstinate, he lays the thing before the session. Elders are chosen from among the most substantial, knowing, and regular people, by the session or consistory of the kirk. There is a ruling elder in every session: he should be a man of spotless character, and of principal consideration and interest in his parish; he is chosen out of the kirk session: the congregation is to approve of the choice: the minister ordains him before the congregation: he may be chosen to assist in any church judicatory, and in all manner of government and discipline, for he has an equal vote with the remainder.

ELECTION, in Numbers, is the different ways of taking any number of quantities given; in combination thus, the quantities *a b c* may be taken different ways, as *a b c*, or *a b*, *a c*, and *a*, *b*, *c*.

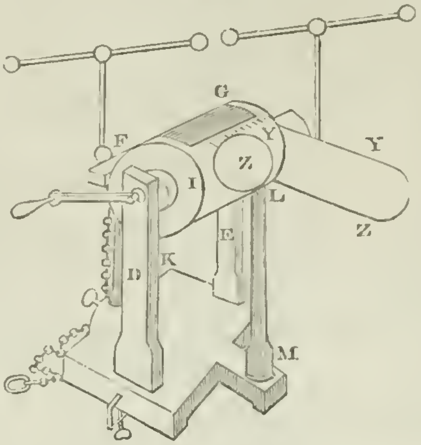
ELECTIVE ATTRACTION. The principle of all chemical operations, which enables us to decompose certain bodies, and to compound others, is, that every substance has a certain peculiar affinity for other substances, but not in an equal degree. Chemical affinity observes certain laws, which are called the *laws of affinity*, and which are as follow:—Chemical affinity exerts its action between a number of bodies, simple or com pound, and unites them chemically into one whole. Soda will combine with sulphuric acid, forming a different substance from either; *viz.* sulphate of soda. The power of chemical affinity is in an inverse ratio to that of corpuscular attraction. The agency of the affinity of composition, or chemical affinity, is either assisted or retarded by different degrees of temperature. Chemical affinity is accompanied by a change of temperature, as in the mixture of sulphuric acid with water. The agency of chemical affinity between two or more bodies, may be dormant until it be called into action by the interposition of another, which frequently exerts no energy upon either of them in a separate state. Metals are not affected by acids until water be present. The degree of energy in chemical affinity acting between various bodies, is different in different substances. Nitric acid has more affinity for potash than for iron. The action of chemical affinity is either limited or unlimited; in other words, chemicals are capable of uniting in definite or in indefinite proportions. The degree of chemical affinity of different bodies, is modified in proportion to the quantities or masses of the substances employed.

ELECTRICITY, the name of an unknown natural power which produces a great variety of peculiar and surprising phenomena, the first of which are supposed to have been observed in the mineral substance called *amber*, whence they have been denominated *electrical phenomena*, and the laws, hypotheses, experiments, &c by which they are explained and illustrated, form together the science of electricity. The electric property of amber was known to Thales, who lived about 600 years before our æra, though Theophrastus, who flourished about 300 years after Thales, is the first author who makes any distinct remark on this subject. Some other of the ancients also speak slightly on this head, but still they confined its action to the two substances amber and jet, and knew nothing farther of its effect except its power of attracting light substances after being excited by friction. Electricity may therefore be considered as a modern science of no higher date than about the year 1600, when Gilbert, a native of Colchester, and a physician in London, published his treatise "De Magnete," in which are contained many considerable experiments and discoveries. Boyle, Otto Guericke, Dr. Wall, and some others, made a few ingenious experiments; but it was not before the year 1709 that any important step had been made in this science. In this year Hawksbee wrote on the subject of electricity, and noticed the great electrical power of glass, and the light proceeding from it; he also first heard the noise attending the excitation, and a variety of other phenomena relating to electrical attraction and repulsion; at the same time he introduced a glass globe into the electrical apparatus; and to this he was indebted for many of his most important discoveries.

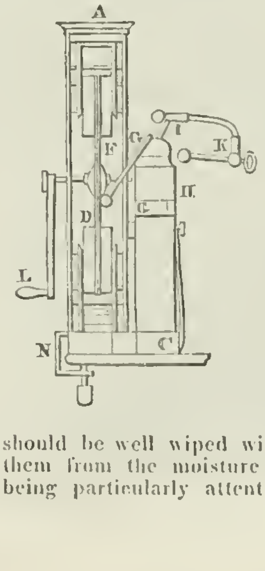
After an interval of twenty years, Stephen Grey established a new æra in the history of electricity. To him we owe the discovery of communicating the power of native electrics to other bodies in which it cannot be excited, by supporting them on silken lines, hair lines, cakes of resin, or glass, and a more accurate distinction than had hitherto obtained between electrics and non-electrics: he also shewed the effect of electricity on water, more obviously than had been done by Gilbert.

The experiments of Grey were repeated by M. du Fay, member of the Academy of Sciences at Paris, to which he added many new observations and discoveries of his own.

Desagulier followed Grey by adding many experiments to the science. But the most remarkable discovery that had yet been made in this science, was in the end of the year 1745, and beginning of 1746. This was the method of giving the electric shock, or the accumulation of the power of electricity in a vial. This had its name of the Leyden Vial, from Cunæus, a native of Leyden, who exhibited it as he was repeating some experiments made by Messrs. Muschenbroek and Allamand, professors in the university of that city. It is said he was not, however, the inventor. The merit of this discovery (if any merit can be ascribed to a discovery made by accident) belongs to Mr. Van Kleist, dean of the cathedral at Camin. Soon after this, however, a method of giving the shock was discovered in Holland, by Cunæus; and the discovery of this powerful effect of the electric fluid immediately raised the attention of all the philosophers in Europe. Electricity rose to that celebrity it has now attained, by the united labours of successive individuals, among whom Cavendish, Priestley, and Franklin, are illustrious.



Electrical *Machine*, denotes the principal part of the electric apparatus, so constructed as to be capable of exciting a great quantity of the electric fluid, and exhibiting its effects in a very sensible manner. A great variety of forms have been given to electrical machines, either for the sake of convenience, or in order to render their effects more powerful; we shall, however, only explain one of the most simple forms, as constructed by the late Mr. Adams, which is represented in the following figure, and may be described as follows:—The cylinder FGHI, is supported by two strong perpendicular pieces DE. The axis of one cap of the cylinder moves in a small hole, at the upper part of one of the supports, and the opposite axis passes through the upper part of the other support. To this end the handle or winch is fitted, and the cushion is supported and insulated by a glass pillar, the lower part of which is fitted into a wooden socket, to which a regulating screw is adapted, to increase or diminish the pressure of the cushion against the cylinder. A piece of silk comes from the under edge of the cushion, and lies on the cylinder, passing between it and the cushion, and proceeding till it nearly meets the collecting points of the conductor. The more strongly this conductor is made to adhere to the cylinder, the stronger is the degree of excitation. Before the cylinder, or opposite to the cushion, is a metallic tube YZ, supported by a glass pillar LM. This is sometimes called the prime conductor, often only the conductor; and for the more conveniently trying experiments on the two powers, and exhibiting the different states of the cushion and conductor, there are two wires to be fixed occasionally, the one to the conductor, the other to the cushion; on the upper part of these are balls furnished with sliding wires, that they may be set apart from each other at different distances. The annexed figure represents another view of the Electrical Plate Machine, the construction of which will be readily comprehended by the different letters which are referred to the same parts in both views.



Before the electrical machine is put in motion, examine those parts which are liable to wear, either from the friction of one surface against another, or to be injured by the dirt that may insinuate itself between the rubbing surfaces. If any grating or disagreeable noise is heard, the place whence it proceeds must be wiped clean, and rubbed over with a small quantity of tallow; a little of which should also be occasionally applied to the axis of the cylinder itself. If the screws by which the frame is fixed are loose, they should be tightened. Having examined the different parts of the machine, and put them in order, the glass cylinder, and the pillars which support the cushion and conductor, should be well wiped with a dry silk handkerchief, to free them from the moisture which glass attracts from the air, being particularly attentive to leave no moisture on the ends of the cylinder, as any damp on these parts carries off the electric fluid, and weakens the force of the machine; in very damp weather it will be proper to dry the whole machine, by placing it at some little distance from the fire. Care should be taken that no dust, loose threads, or filaments, adhere to the cylinder, its frame, the conductors, or their insulating pillars; because these will gradually dissipate the electric fluid, and prevent the machine from acting powerfully. When you are satisfied of this, rub the glass cylinder first with a clean, coarse, dry, warm cloth, or a piece of wash leather, and then with a piece of dry, warm, soft silk; do the same to all the glass insulating pillars of the machine and apparatus; these pillars must be rubbed more lightly than the cylinder, because, being varnished, they may be damaged by too much friction.

We come now to consider *electrics* and *conductors*, which may be disposed according to the order of their perfection, beginning in each column with the most perfect of their class. Thus, *glass* is a more perfect *electric* than *amber*, and *gold* is a better *conductor* than *silver*.

Electrics.	*Conductors.*
Glass of all kinds.	All the metals in the following order:
All precious stones, the most transparent the best.	Gold, silver, platina, brass
Amber. Sulphur.	Iron, tin, quicksilver, lead.
All resinous substances.	The semi metals.
Wax, silk, and cotton.	Metallic ores.
Dry external animal substances, as feathers, wool, & hair.	Charcoal.
Paper. Loaf sugar.	The fluids of the animal body.
Air, when dry.	Water, especially salt water, and other fluids, except oil.
Oils and metallic oxides.	Ice, snow.
Ashes of animal and vegetable substances.	Most saline substances.
Most hard stones.	Smoke, steam, and even a vacuum.

Professor Lapostolle, of Amiens, has discovered that straw possesses the quality of serving as a conductor to lightning and hail. Repeated experiments have convinced him, that straws united together serve equally well as the iron rods now fixed upon buildings for the former purpose, at the same time that they are not attended with similar inconvenience. In consequence of this discovery, the common buildings may be secured from the effects of lightning in the most economical manner; and even crops on the land may be protected from the ravages which they sometimes suffer from hail.

It may be proper in some cases to place a hot iron on the foot of the conductor, in order to evaporate the moisture which would otherwise injure the experiments. It may also be observed, that, 1. To excite the machine, it is requisite to clean the cylinder, and wipe the silk. 2. Grease the cylinder, by turning it against a greasy leather, till it is uniformly obscured. The tallow of a candle will answer this purpose. 3. Turn the cylinder till the silk flap has wiped off so much of the grease as to render it semi-transparent. 4. Spread some amalgam on a piece of leather, and apply this against the turning cylinder. By this means the friction will immediately increase, and the leather must not be removed till it seems to have attained its maximum; then discontinue the application of it, and the effect of the machine will be found very powerful. The best kind of amalgam is made of zinc and quicksilver. If a little of the latter be added to melted zinc it renders it easily pulverizable, and more quicksilver must be added to the powder if very soft amalgam is required.

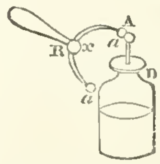
The following statement seems to comprise the general principles on which this wonderful fluid is known to act:—The *electric fluid* is probably the same in essence with that of light and heat, but combined with a substance which affects the organs of smell. When bodies are electrified by glass, they furnish tufts or pencils of light; but if electrified by sulphur, they only produce points or sparks of light; bodies presented to those electrified by glass produce only luminous sparks; while those which are presented to bodies which are electrified by sulphur, present beautiful pencils or tufts of light.

Bodies are electrified either by *friction* or *communication*. To electrify bodies by communication, it is necessary to insulate them; and the substances most proper for insulating others, are those which electrify best by friction. Glass electrifies both by friction and communication, and the energy of the fluid is augmented in the conductors by an increase of surface. The pencils or tufts of light, seen at the extremities of electrified bodies, are composed of divergent rays when they pass through the air, but to pass a permeable conducting body, they sometimes become convergent.

Animal Electricity.—Some fishes have the property of giving shocks analogous to those of artificial electricity; namely, the *torpedo*, the *gymnotus electricus*, and the *silurus electricus*. If the torpedo, whilst standing in water, or out of water, but not insulated, be touched with one hand, it generally communicates a trembling motion or slight shock to the hand. If the torpedo be touched with both hands at the same time, one hand being applied to its under and the other to its upper surface, a shock will be received exactly like that occasioned by the Leyden phial. The shock given by the torpedo when in air, is about four times as strong as when in water; and when the animal is touched on both surfaces by the same hand, the thumb being applied to one surface, and the middle finger to the opposite, the shock is felt much stronger than when the circuit is formed by both hands. The gymnotus electricus, or electrical eel, possesses all the electric properties of the torpedo, but in a superior degree. When small fish are put into the water wherein the gymnotus is kept, they are generally stunned or killed by the shock, and then they are swallowed, if the animal be hungry. The strongest shock of the gymnotus will pass a very short interruption of continuity in the circuit. When the interruption is formed by the incision made by a penknife on a slip of tinfoil that is pasted on glass, and that slip is put into the circuit, the shock, in passing through that interruption, will shew a small but vivid spark, plainly to be seen in a dark room. The gymnotus seems also to be possessed of a sort of *new sense*, by which he knows whether the bodies presented to him are conductors or not. This fact has been ascertained by a great number of experiments.

Electrical Instruments and Apparatus.—The experiments in electricity are so various, that the apparatus used may be increased almost agreeably to every man's fancy; and in general, he who wishes to make new experiments, will find it necessary to make an addition suitable to the object of his inquiry. It will be, therefore, most consistent with the design of this work, to describe only those parts of the apparatus which are most essential to the performance of popular experiments. The instruments commonly employed in this branch of science may be classed under six heads:—1st. The instruments used for *exciting* electricity, *viz.* glass tubes, plates, and cylinders; 2nd. Those for *conducting* the electric matter, which are chiefly METALS; 3rd. Those intended for *accumulating* the fluid, or, in technical language, for *receiving a charge*, such as coated bottles or jars, commonly called LEYDEN PHIALS; 4th. Those which are intended to *produce more formidable effects*, such as ELECTRIC BATTERIES; 5th. The instruments employed for *ascertaining the quantity of electricity*, called ELECTROMETERS; and lastly, those employed for *retaining* the electric power.

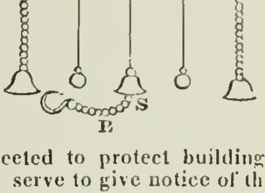
The discharging rod needs no explanation: it is shewn in the figure, R, as applied to a *Leyden Phial*, A D. This jar is coated with tinfoil on the inside and outside, within about three inches of the top of its cylindrical part, and having a wire with a round brass knob, or ball, A, at its extremity. This wire passes through the cork, or wooden stopper, D; at its lowest extremity is a piece of chain that touches the inside coating in several parts. To charge this jar, a communication is made between the electrical machine and the brass knob A, while the outside of the jar communicates with the earth by the table or the hand. Bring the knob A of the jar near the prime conductor, and after a few turns of the machine the jar will be charged; that is, the inside of the jar will be positively, and the outside negatively, electrified; or if the inside is negatively, the outside will be positively, electrified. R is a discharging rod, which is used to convey the superabundant electricity from one side to the other, where there is less than the natural share. The discharging rod consists of two brass knobs, *a a*, attached to wires, which move round a joint *x*, fixed to a glass handle R. The operator



holds the discharging rod by the glass handle R, and applies the brass knobs to the ball and jar, as shewn in the figure, when an explosion takes place proportional to the quantity of electricity it had received. If any number of persons join hands, and one holds a chain that is in communication with the jar, while the last of the company touches the jar, a shock will be received.

Of the Electric Spark.—The spark that shines between the two bodies is capable of setting *combustible* matters on fire. If a body, containing only its natural share of electricity, be presented sufficiently near to a body electrified, *positively* or *negatively*, a quantity of electricity will force itself through the air, from the latter to the former, appearing in the form of a *spark*. When two bodies approach each other sufficiently near, one of which is electrified *positively*, and the other *negatively*, the superabundant electricity rushes violently from one to the other, to restore the equilibrium between them. This effect takes place if the two bodies be connected by a conducting substance. The electric spark has not only the appearance of fire, but is capable of actually setting fire to various substances that are easily inflamed. The sense of feeling, seeing, and hearing, are not only affected by electricity, but it is even sensible to the smell and the taste. The electric spark goes to a greater or less distance through the air, in order to reach a conductor, according as its quantity is greater or less; as the parts from which it proceeds, and on which it strikes, are sharper or more blunt, and as the conductor is more or less perfect. The strength of the machine is known from the length and density of the sparks it gives.

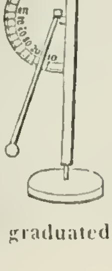
That the charge of a coated jar resides in the glass, and not in the coating, is proved in the following manner:—Set a plate of glass between two metallic plates, about two inches in diameter, smaller than the plate of glass; charge the glass, and then remove the upper metallic plate; by an insulated handle, take up the glass plate, and place it between two other plates of metal which have not been electrified, but insulated—the plate of glass thus coated afresh will still remain charged.



The Electrical Bells consist of three small bells suspended from a narrow plate of metal, the two outermost by chains, and that in the middle (from which a chain, S R, passes to the floor) by a silken string. Two small knobs of brass are also hung by silken strings, on each side of the bell, which serve as clappers. If an apparatus of this kind is joined to one of those conducting rods erected to protect buildings from the effect of lightning, it will serve to give notice of the approach and passage of an electrical cloud.

The Electrical Battery has been described; *see* BATTERY.

The instruments for ascertaining the presence and the quantity of electricity in different bodies are various, but the simplest of all are little balls of cork, or rather of the pith of elder, which is still lighter, and suspended by silk threads. When brought into contact with an electrified body, the balls will immediately diverge, and, according to the degree of divergence, a judgment may be formed of the degree to which the body in question is electrified. A similar effect will be produced by a light and downy feather. The pith balls are called *Canton's electrometer*.



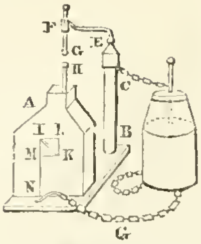
For more particular admeasurement, that is, for ascertaining precisely the degree to which any body is electrified, an instrument somewhat less simple is required, and the *quadrant electrometer*, as in the figure, is in most general use. It consists of a perpendicular stem formed at the top like a ball, and furnished at its lower end with a brass ferule and pin, by which it may be fixed in a hole made in the conductor of the *electrical machine* or of a *Leyden jar*. To the upper part of the stem a graduated ivory semicircle is fixed, about the middle of which is a brass arm or cock, to support the axis of the index. The index is a very slender stick, which reaches from the centre of the graduated arch to the brass ferule, and to its lower extremity is fastened a small pith ball, nicely turned in a lathe. When this electrometer is in a perpendicular position, and not electrified, the index hangs parallel to the pillar; but when it is electrified, the index recedes more or less, according to the quantity of electricity. Lane's discharging electrometer, as it is commonly called, is employed chiefly by the practitioners of medical electricity.

Medical Electricity.—In judging of cases proper to be electrified, experience shews, that in general, all kinds of obstructions, whether of motion, of circulation, or of secretion are very often removed or alleviated by electricity. The same also may be said of nervous disorders; both which include a great variety of diseases. The application of electricity has also been found a powerful remedy in muscular contractions. But when any limb is deprived of motion, it must be observed, that the deprivation has not always originated in a contraction of the muscles, but that it is often occasioned by relaxation; thus, for instance, if the hand be bent inwardly, the patient has no power of straightening it; the cause of it may be a weakness of the outward muscles, as well as a contraction of the inward ones. In such cases, it is difficult, even for anatomists, to discover the real cause; but the surest method is to electrify not only those muscles which are supposed to be contracted, but also their antagonists; for, to electrify a sound muscle is by no means hurtful. Rheumatic disorders of long standing are relieved, and frequently cured, by only drawing the electric fluid with a point from the part, or by drawing sparks from the conductor; the operation should be continued for about four or five minutes, repeating it once or twice every day. When strong shocks are administered, their greatest number should not exceed 12 or 14, except when they are to be given to the whole body in different directions. The instruments, which, besides the electrical machine and its prime conductor, are necessary for the administration of medical electricity, may be reduced to three, *viz.* an electric jar, with Lane's electrometer; an insulated chair, or an insulated stool, upon which a chair may be occasionally set, and the directors.

The Identity of Lightning and Electricity.—Dr. Franklin proved, by a variety of experiments, that the lightning spark of electricity, and the lightning that flashes from the clouds in a thunder storm, are exactly of the same kind, and operate in the same manner, &c. The particulars in which lightning and the electric fluid agree, are, 1. Flashes of lightning are generally seen crooked, and waving in the air, as the electric spark, when it is drawn from an irregular body at some distance. 2. Lightning strikes the highest and most pointed objects in its way, in preference to others; as high hills, and trees, towers, spires, masts of ships, points of spears, and the like. In like manner, all pointed conductors receive or throw off the electric fluid more readily than those that are terminated by flat surfaces. 3. Lightning is observed to take the readiest and best conductor. So does electricity in the discharge of the Leyden phial. For this reason Dr. Franklin supposes, that it would be safer, during a thunder storm, to have one's clothes wet than dry, as the lightning might then, in great measure, be transmitted to the ground, by the water on the outside of the body. It is found, he says, that a wet rat cannot be killed by the explosion of the electrical bottle, but that a dry rat may. 4. Lightning causes combustion, so does electricity. Dr. Franklin says, that he could kindle with it, hard dry resin, spirits unwarmed, and even wood. 5. Lightning sometimes dissolves metals: so does electricity. 6. Lightning has often been known to strike people blind. And a pigeon, after a violent shock of electricity, by which the doctor intended to have killed it, was observed to have been struck blind. 7. Lightning destroys animal life. Animals have likewise been killed by the shock of electricity. The largest animals which Dr. Franklin and his friends have been able to kill, were a hen, and a turkey which weighed about ten pounds.

Thunder is merely the noise produced by the motion of lightning. The reason why we do not hear the dreadful noise of the thunder, as soon as we see the lightning, is, because sound is longer in arriving to our ears, than light to our sight. Light moves almost instantaneously. Sound moves no more than 1142 feet in a second.

The Thunder House Experiment.—The effects of the electric matter, when it strikes a building, and the method of preventing it, are exemplified by an instrument called the *thunder house*, representing the side of a house, either furnished with a metallic conductor or not. A is a board about three-quarters of an inch thick, and shaped like the gable end of a house. This board is fixed perpendicularly upon the bottom board B, upon which the perpendicular glass pillar C is also fixed, in a hole about eight inches distant from the basis of A. A small hole I L K M, about one-fourth of an inch deep, and nearly one inch wide, is made in the board A, and is filled by a square piece of wood of nearly the same dimensions, it being necessary that it should fit the hole, in order to drop out by the least shaking of the instrument. A wire I K, is fastened diagonally to this square piece of wood. Another wire L H, of the same thickness, having a brass ball, H, screwed on its pointed extremity, is fastened on the board A, so also is the wire M N, which is shaped in a ring at N. From the upper extremity of the glass pillar C, a crooked wire proceeds, having a spring socket F, through which a double-knobbed wire slips perpendicularly, the lower knob G of which falls just above the knob H. The glass pillar C must not be made very fast in the bottom board, but it must be fixed so that it may be easily moved round its own axis, by which means the brass ball G may be brought either nearer or farther from the ball H without touching the part E F G. Now when the square piece of wood L I M K (which may represent the shutter of a window or the like) is fixed into the hole, so that the wire I K stands in the direction L M, then the metallic communication from H to N is complete, and the instrument resembles a house furnished with a proper conductor; but if the square piece of wood L I M K is fixed, so that the wire I K stands in the direction I K, as represented in the figure, then the metallic conductor H N, from the top of the house to its bottom, is interrupted at L N, in which case the house is not properly secured.



Fix the piece L I M K, so that the wire may be as represented in the figure, in which case the metallic conductor H N is discontinued. Let the ball G be fixed perpendicularly about half an inch distance from the ball H M, only turning the glass pillar C, remove the former ball from the latter; by a wire or chain, connect the wire E F with the wire G of the jar P, and let another wire or chain, fastened to the hook N, touch the outside coating of the jar. Connect the wire G with the prime conductor, and charge the jar; then by turning the glass pillar C, let the ball G come gradually near the ball H, and when they are arrived sufficiently near one another, the jar will be discharged, and the piece of wood L I M K will be pushed out of the hole to a considerable distance from the thunder house. The ball G in this experiment represents an electrified cloud, which, when it arrives sufficiently near the top of the house A, discharges into it the electric fluid; and as the house is not secured by a proper conductor, the explosion breaks part of it, *i. e.* knocks out the piece of wood I M. Repeat the experiment; but let the piece of wood I M be so situated, that the wire I K may stand in the situation L M, by which the conductor H N will not be discontinued: in this case the explosion will have no effect upon the piece of wood L M, which shews the utility of metallic conductors for houses.

Variation in this Experiment.—Unscrew the brass ball H from the wire H L, so that it may remain pointed, and with only this difference in the apparatus, repeat these two experiments; the piece of wood L N will remain immoveable, and no explosion will be heard. The conductor E F G in this experiment is supposed to represent a thunder cloud discharging its contents on a weathercock, or any other metallic substance on the top of a building; hence it may be inferred, that if there is a metallic communication to conduct the electric fluid down to the earth, the building will receive no damage; but where the connexion is imperfect, it will strike from one part to the other, and thus endanger the whole building. Elevated conductors applied to buildings to secure them from lightning, will in this manner discharge the electricity from a cloud that passes over them.

Electrical Phenomena.—The various phenomena of electricity may be divided into four classes, in the first of which may be included all those experiments which serve to illustrate electrical attraction and repulsion; in the second, those produced by the stream of electricity; in the third class may be ranged all those phenomena which are accompanied with luminous appearance; and, lastly, we may enumerate those more formidable effects arising from the concentrated electricity, in the experiments with the Leyden phial and the electrical battery.

There is a stone found in many parts of the world called *tourmalin*, which is sometimes crystallized as a nine-sided prism, terminated by a three-sided and a six-sided pyramid; when this substance is gently heated, it becomes electrical, and one extremity, that terminated by the six-sided pyramid, is positive, the other is negative: to a certain extent, its electricities are exalted by increasing the temperature; when it begins to cool, it is still found electrical; but the electricities are changed, the pyramid, before positive, is now negative, and vice versa. When the stone is of considerable size, flashes of light may be seen along its surface. There are other gems and crystallized substances, which possess a property similar to that of the tourmalin. The luminous appearance of some diamonds, when heated, probably depends upon their electrical excitation. The substance called the *boracite*, which is a cube, having its edges and angles defective, becomes electrical by heat, and in one variety presents no less than eight sides, in different states, four positive, four negative; and the opposite poles are in the direction of the axes of the crystal.

ELECTUARY, in Pharmacy, a form in which both official and extemporaneous medicines are frequently made.

ELEGIT, in Law, a writ of execution, which lies for a person who has recovered debt or damages; or upon a recognizance in any court, against a defendant that is not able to satisfy the same in his goods.

ELEMENTARY, any thing relating to the principles or elements of bodies.

ELEMENT, in Physiology, a term used by philosophers, to denote the original component parts of bodies, or those into which they are ultimately resolvable. It was the opinion of the ancient philosophers that there are only four simple bodies; namely, fire, air, water, and earth. To these they gave the name of elements, because they believed that all substances are composed of them. But we now know that these supposed elements are compounds: fire is composed of caloric and light; air of caloric, oxygen, and azotic gases; water of oxygen and hydrogen; and the earth includes various different substances.

ELEMENTS OF THE PLANETS, in Astronomy. *See* PLANET.

ELEMENTS *of Geometry*, the title of a celebrated and well-known work of Euclid. *See* GEOMETRY.

ELEMENTS, in the Higher Geometry or Analysis, denotes indefinitely small portions of curves, surfaces, and solids.

ELEMENTS, in Physics, the first principles, or ingredients, of which bodies are composed. These are supposed to be few in number, unchangeable, and by their different combinations producing that extensive variety of objects which constitute the works of nature.

ELEMENTS *of Bodies*, in Chemistry. When we contemplate the world that we inhabit, we discover a vast variety of substances differing in their properties of weight, colour, &c. from each other. When we examine these more minutely, we discover also that almost all the bodies with which we meet, are of a mixed or compound nature. When we reduce these to the principles of which they are composed, we find that the number of simple or unmixed bodies is very limited, and that all the substances with which we are acquainted, are formed from a combination, in various proportions, of these simple bodies. The *elements of bodies*, then, are those simple substances, of which, in various proportions or combinations, all bodies with which we are acquainted are composed. Formerly, air, earth, fire, and water, were supposed to be the elements of which all bodies are formed. But modern improvements in chemistry have shewn that this was an erroneous supposition. For it is well known that the air or atmosphere is a mixed body, composed of several aërial fluids or gases, so that instead of one simple kind of air, it is now known that there are several sorts of air, essentially different from each other. It is also known, that instead of one simple kind of earth, there are several kinds, quite different. Water is found not to be a simple body, but composed of two different kinds of air united together. With the nature of fire we are very little acquainted; but this we can say, that combustible substances, either burning or otherwise, are not simple substances. From the improvements that are continually making in the methods of analyzing bodies, or separating them into their component principles or elements, many substances, once supposed to be simple, are found to be compounds; and as chemistry continues to improve, more errors of this kind may be corrected, and our inability to decompose any substance, does not prove it to be a simple body or an element, but only, perhaps, that our methods of analysis are not perfect. For the sake of convenience, however, we shall at present consider all bodies as elements or simple bodies, that have not been analyzed or separated into component parts.

Almost every body in nature is susceptible of three several states of existence; *viz.* solid, liquid, and aëriform; and these states of existence depend upon the quantity of caloric combined with the body. The simple substances at present known are divided into three classes; *viz.* imponderable bodies, as caloric, and light. Supporters of combustion, as oxygen, chlorine, iodine, and fluorine. Combustible and incombustible substances, as carbon, sulphur, phosphorus, hydrogen, nitrogen, boron, silicon, and the metals.

ELEPHANT, Elephas, a genus of the mammalia class, of the order bruta. The generic character is, cutting-teeth none in either jaw; tusks in the upper jaw; proboscis very long, prehensile; body nearly naked. There are two species, 1. The elephas maximus, the great elephant. 2. The sukotyro. The teeth, which are imported into Europe, are generally from Africa, where they are frequently found in woods. The elephant is undoubtedly the largest of all terrestrial animals, arriving at the height of twelve feet, though the more general height seems to be from nine to ten feet. Elephants are commonly found in the midst of shady woods, and they delight in cool spots, near rivers. They are capable of swimming with great ease. Their general food consists of the tender branches of various trees, as well as grains and fruits. The elephant brings usually one young at a time; rarely two; the young are about three feet high when they are first born, and continue growing till they are sixteen or twenty years old; they are said to live a hundred or a hundred and twenty years. The sukotyro, a native of Java, according to Nieuhoff, who has figured in his travels to the East Indies, is a quadruped of a very singular shape. Its size is that of a large ox; and the snout like that of a hog; the ears round and rough; and the tail thick and bushy. The eyes are placed upright in the head, quite differently from those of other quadrupeds. On each side the head, stand the horns, or rather teeth, not quite so thick as those of an elephant. This animal feeds upon herbage, and is but seldom taken.

ELEVATION, denotes the height or altitude of any object.

Elevation *of the Equator*, in Astronomy, is an arch of the meridian, less than a quadrant, intercepted between the equator and the horizon of the place.

Elevation *of the Pole*, is an arch of the meridian intercepted between the pole and the horizon of the place.

Elevation *of a Star*, is an arch of a vertical circle contained between a star and the horizon, and in the same manner is estimated the elevation of any other of the heavenly bodies.

Elevation *of a Piece of Ordnance*, in the theory and practice of projectiles, is the angle the axis of the gun makes with the horizon.

Elevation, *Angle of*, in Gunnery, that comprehended between the horizon and the line of direction of a cannon or mortar; or it is that which the chase of a piece, or the axis of its hollow cylinder, makes with the plane of the horizon.

Elevation, in Perspective, the representation of the whole body or building, as in architecture, elevation signifies the whole or principal face of a building.

ELGEBAR, the name of the bright star in the foot of Orion, more commonly called Rigel.

ELIMINATION, in Analysis, that operation by means of which all the unknown quantities except one are exterminated out of an equation, whence the value of that one becomes determined, and hence by substitution the value of all the other quantities.

ELISION, in Grammar, is the cutting off a vowel or syllable in a word, as in "*th' attempt*," where *e* is cut off, because coming before a vowel.

ELIXIR, in Medicine, a compound tincture, extracted from many efficacious ingredients; hence, the difference between a tincture and an elixir seems to be this:—A tincture is drawn from one ingredient, as the tincture of rhubarb, or sometimes with an addition of another, to open it, and to dispose it to yield to the menstruum; whereas an elixir is a tincture extracted from several ingredients at the same time.

ELK, an animal of the deer kind, with the horns palmated, and without a stem. It is a native of the northern parts of Europe, and is a strong animal, equal in size to a horse, but far less beautiful.

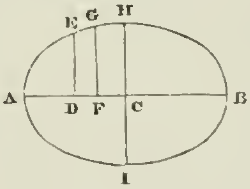
ELL, a measure which obtains, under different denominations, in most countries, whereby cloths, stuffs, linens, silks, &c. are usually measured. The ell English, is 5 quarters, or 45 inches; the ell Flemish, 3 quarters, or 27 inches. In Scotland, an ell contains 37 $\frac{2}{10}$ inches English.

ELLIPSE, is one of the conic sections, formed by the intersection of a plane and cone, when the plane makes a less angle with the base than that formed by the base and the side of the cone.

The word is derived from *ἐλλεπης*, *defective*, and is thus denominated by Apollonius, because the square of the ordinate in this figure is always less than the rectangle of the parameters and abscisses.

There are three ways in which we may define an ellipse; *viz.* 1. As being produced by the intersection of a plane and cone, as we find it treated of by Apollonius and all the ancients. 2. According to its description in plano, as it is treated of by several of the moderns. And 3. As being generated by the motion of a variable line or ordinate, along another line or directrix, whereby the properties of the curve are treated of, by means of the equation by which it is defined.

The several lines and points in and about an ellipse, as the axis, diameters, parameter, foci, &c. will be found defined and explained under the several articles in this Dictionary; and we shall, therefore, in this place merely state some of the principal properties of the figures, without, however, attempting their demonstration, as that would extend this article to too great a length.



Properties of the Ellipse.—1. The squares of the ordinates of the axis, are to each other as the rectangle of the abscisses. That is,

$$AF . FB : GF^2 :: AD . DB : DE^2$$

Or if one of the ordinates be taken at the centre as H C, which thus become the semiconjugate, then because AC . CB = AC², the proportion becomes

$$AC^2 : CH^2 :: AD . DB : DE^2$$

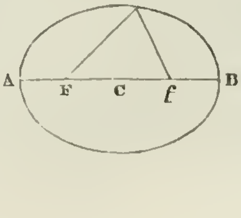
or by doubling

$$AB^2 : HI^2 :: AD . DB : DE^2$$

That is, As the square of the transverse axis
Is to the square of the conjugate,
So is the rectangle of the abscisses
To the square of their ordinate.

2. The sum of two lines drawn from the two foci to any point in the curve is always equal to the transverse axis.

Fig. 1.

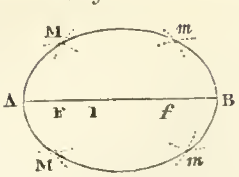


That is, if F. *f*, be the two foci, and F E, *f* E, two lines drawn from them to any point E in the curve, then F E + *f* E = A B, fig. 1.

From this property is derived the common method of describing the curve mechanically by points, or by a thread thus, fig. 2:

In the transverse axis take the foci F, *f*, and any point I. Then will the radii A I, I B, describe, from the centres F, *f*, two arcs intersecting each other in M, which will be a point in the curve. In like manner assume other points I, and thus determine other points *m*, *m*, &c. Then with a steady hand a curve-line may be drawn through all the points of intersection, which will be the ellipse required.

Fig. 2.



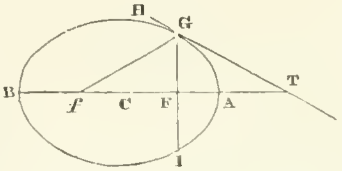
Or, otherwise, take a thread of the length A B the transverse axis, and fix its two ends in the foci F, *f*, (see fig. 2.) Then carry a pen or pencil P, round by the thread, keeping it always stretched, and its point will trace out the ellipse, as is evident from the property above stated.

Other methods of describing the ellipse in plano are given in the subsequent part of this article.

3. If a tangent be drawn to any point in an ellipse, and two lines drawn from the two foci to the point of contact, these two lines will form equal angles with the tangent.

That is, if H T be a tangent to the ellipse at G, and the two lines F G, *f* G from the two foci be drawn, then will the angle T G F = the angle H G *f*.

It is this property that gives the name foci to the two points F, *f*, for as opticians find that the angle of incidence is equal to the angle of reflection; it follows from the above property, that rays of light issuing from the one focus, and meeting the curve in every point, will be reflected back into the other focus, and hence these points are denominated *foci*, or *burning points*.

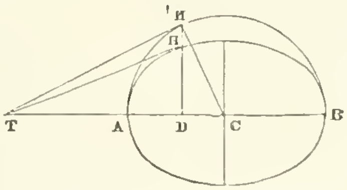


This property may be otherwise illustrated by considering a billiard table in the form of an ellipse, then a ball being struck so as to pass through one focus in any direction, it will be reflected back again through the other focus, then again through the first, and so on, as long as the ball continues in motion.

4. If there be any number of ellipses described on the same transverse axis, and any ordinate be drawn so as to meet all those ellipses, the tangents to the several ellipses at those points will all terminate in one common point in the prolongment of the transverse axis.

That is, if A H B, A H′ B, be any two ellipses, having the same transverse axis; and D H H′ be any common ordinate, then the two tangents H T, H′ T, will be terminated in the common point T.

And as this is necessarily true when A H′ B becomes a circle, we have hence an easy method of drawing a tangent to any point in an ellipse; which is as follows:



Let H be the point to which a tangent is to be drawn; draw the right ordinate D H, and produce it indefinitely; on A B describe a semicircle meeting the ordinate produced in H′; join H′ C, and draw H′ T perpendicular to H′ C, meeting the transverse produced in T, then T H will be the tangent required.

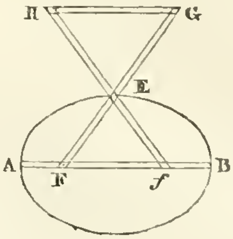
5. The ordinate H′ T, in the circle, is to the ordinate H T of the ellipse, as the transverse axis of the ellipse is to its conjugate axis. And if a circle were described on the conjugate axis, and an ordinate drawn as before, then the ordinate of the circle would be to the corresponding ordinate in the ellipse, as the conjugate axis of the ellipse is to its transverse. And hence it follows that the area of any ellipse is a mean proportional between the area of the circles described on its two axes.

6. Every parallelogram circumscribed about an ellipse, at the extremities of any pair of its conjugate diameters, is equal to the rectangle of its two axes.

7. The sum of the squares of any pair of conjugate diameters is always equal to the sum of the squares of the two axes of the ellipse.

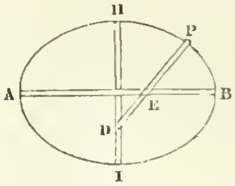
Description of the Ellipse in plano.—Besides the two methods of describing an ellipse, given in proposition 2, there are several others, by instrumental operation, of which the following are the most simple:

Fig. 1



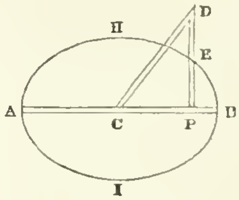
1. If two rulers F G, *f* H, fig. 1. each equal in length to the transverse axis A B, have their extremities fixed in the foci so as to be moveable round these points; and if the other extremities of the rulers be connected by a third ruler H G, which is equal in length to F *f*, the distance of the two foci so as to be moveable about the two points H and G; then if the ruler H G be moved round the centres F and *f*, the intersection of the rulers F G, *f* H, in E will describe the periphery of an ellipse, of which A B is the transverse axis, and F, *f*, the two foci.

Fig. 2.



2. Let there be two rulers, A B, H I, fig. 2. set at right angles to each other, and let a third ruler, D E P, be moved along, so that the points D and E constantly touch the two rulers A B, H I; so will the point P describe the periphery of an ellipse. On this principle are constructed ELLIPTIC *Compasses*, which *see*.

Fig. 3.



3. If one end C, fig. 3. of any two equal rulers C D, D P, which are moveable about the point D, like a carpenter's joint rule, be fastened to the ruler A B, so as to be moveable about C; and if the end P, of the ruler D P, be drawn along the side of the ruler A B, then any point E, taken in the side of the ruler D P, will describe an ellipse whose centre is C, conjugate axis = 2 E P, and transverse = 2 C D — 2 D E.

Area of an Ellipse.—Multiply the two axes together, and that product again by ·7854, which will be the area required.

Area of an Elliptic Segment.—Find the area of the corresponding circular segment, described on the same axis to which the cutting line or base of the segment is perpendicular. Then as this axis is to the other axis, so is the circular segment to that of the ellipse. Or, find the tabular circular segment whose versed sine is equal to the quotient, of the height of the elliptic segment divided by its axes. Then multiply together this segment, and the two axes of the ellipse, for the area of the segment.

ELLIPSIS, in Grammar, a figure in syntax, in which one or more words are not expressed.

ELLIPTIC, or ELLIPTICAL, something relating to an ellipse.

ELLIPTIC *Arc*, is any part of the periphery of an ellipse.

ELLIPTIC *Compasses*. *See* COMPASSES.

ELLIPTIC *Conoid*, the same as spheroid.

ELLIPTIC *Dial*, an instrument usually made to fold up for the convenience of the pocket. By this dial is found the meridian, hour of the day, the rising and setting of the sun, &c.

ELLIPTIC *Spindle*, is the solid generated by the revolution of any segment of an ellipse about its chord.

ELLIPTICITY of the TERRESTRIAL SPHEROID, is the difference between the major and the minor semiaxes; it is generally expressed in terms of the former, that is, of the radius of the equator. The quantity of the ellipticity has been variously assigned by different mathematicians: Sir Isaac Newton, supposing the earth of uniform density, gave $\frac{1}{230}$ for the ellipticity; Boscovich, from a mean of several admeasurements, stated it at $\frac{1}{248}$; Lalande, $\frac{1}{331}$; Laplace, $\frac{1}{321}$; Sejour, $\frac{1}{307}$; Carouge, $\frac{1}{300}$; Krafft, $\frac{1}{297}$; and Playfair, from a theorem of Clairault applied to the heterogeneous spheroid, states it at $\frac{1}{304}$. Setting aside those which are deduced from the hypothesis of uniform density, $\frac{1}{320}$ may be admitted as the most probable value of the ellipticity.

ELOGY, praise or panegyric bestowed on any person or thing, in consideration of its merit. The beauty of elogy consists in brevity. Eulogiums should not have so much as one epithet properly so called, nor two words synonymous. They should strictly adhere to truth; for extravagant and improbable elogies lessen the character of the person they would extol.

ELONGATION, in Astronomy, the angle under which we see a planet from the sun, when reduced to the ecliptic, or it is the angle formed by two lines drawn from the earth to the sun and planet, when reduced as above. The greatest elongation is the greatest distance to which the planets recede from the sun, which, however, only relates to the inferior planets Mercury and Venus; for it is obvious, that any of the superior planets may be 180° distance from the sun, or in opposition. The greatest elongation of Venus, according to our modern tables, is from 44° 57′ to 47° 48′, and that of Mercury from 17° 36′ to 28° 20′.

ELOPEMENT, is, when a married woman of her own accord departs from her husband, and dwells with an adulterer; for which, without voluntary reconciliation to the husband, she shall lose her dower. Except that her husband willingly, and without coercion of the church, reconcile her, and suffer her to dwell with him, in which case she shall be restored to her action. By eloping and living apart from the husband, he is discharged of the future debts, and no longer liable to support her.

ELVELA, a genus of plants belonging to the cryptogramia class, and the order of *fungi*.

ELYMUS, a genus of plants belonging to the class triandria, and in the natural method ranking under the 4th order *gramina*.

EMBALMING, is the opening of a dead body, and having taken out the entrails, filling it with odoriferous drugs and spices, to prevent its putrefying, and then pickling it in a solution of nitre for two months and a half. The body was then wrapped up in bandages of fine linen and gums, and magnificently painted, and placed in a coffin or sarcophagus.

EMBARGO, in Commerce, an arrest on ships, or merchandise, by public authority; or a prohibition of state, commonly on foreign ships, in time of war, to prevent their going out of port; sometimes to prevent their coming in; and sometimes both for a limited time.

EMBASSADOR, or AMBASSADOR, a public minister sent from one sovereign prince, as a representative of his person, to another. Embassadors are either ordinary or extraordinary.

EMBAYED, the situation of a ship when she is enclosed between two capes or promontories; it is particularly applied when the wind, by blowing strong into any bay or gulf, makes it extremely difficult, and perhaps impracticable, for the vessel thus enclosed to draw off from the shore, so as to weather the capes and gain the offing.

EMBER WEEKS, or *Days*, in the Christian church, are certain seasons of the year set apart for the imploring God's blessing, by prayer and fasting, upon the ordinations performed in the church at such times. The ember weeks were formerly observed in different churches with some variety, but were at last settled as they are now observed, by the council at Placentia, anno 1095.

EMBERIZA, a genus of birds belonging to the order of passeres, of which there are 24 species, among which the most remarkable are, The nivalis, or great pied mountain-finch of Ray, and the snow-bird of Edwards: it has white wings, but the outer edges of the prime feathers are black; the tail is black, with three white feathers on each side. These birds are called in Scotland snow-flakes, from their appearance in hard weather. They arrive in that season among the Cheviot-hills, and in the Highlands in flocks. The miliaris, or gray emberiza, is of a grayish colour, spotted with black on the belly, and the orbits are reddish. It is the bunting of English authors. The hortillana, or ortolan, has black wings; the first three feathers on the tail are white on the edges, only the two lateral are black outwardly. The orbits of the eyes are naked and yellow; the head is greenish, and yellow towards the inferior mandible. It feeds principally upon the millet, grows very fat, and is reckoned a delicate morsel by certain epicures, especially when fattened artificially.

EMBEZZLEMENT, the act of a servant secreting or making away with property intrusted to him. It is felony, and subjects the offender and his abettors to transportation.

EMBOLIMÆAN, and EMBOLISMIC, *Intercalary*, is chiefly used in speaking of the additional months inserted by chronologists to form the lunar cycle of 19 years.

EMBOLISMUS, in Chronology, signifies intercalation. As the Greeks made use of the lunar year, which is only 354 days, in order to bring it to the solar, which is 365 days, they had every two or three years an embolism, *i.e.* they added a 13th lunar month every two or three years, which additional month they called *embolimæus*, because inserted or intercalated.

EMBOLUS the piston or sucker of a pump.

EMBOSSING, or IMBOSSING, in Architecture and Sculpture, the forming or fashioning works in relievo, whether cut with a chisel or otherwise.

EMBRACERY, an attempt to corrupt or influence a jury, or any way incline them to be more favourable to the one side than the other, by money, promises, letters, threats, or persuasions; whether the juror give verdict or not, or whether the verdict given be true or false, which is punished by fine and imprisonment; and the juror taking money, perpetual infamy, imprisonment for a year, and forfeiture of tenfold the value.

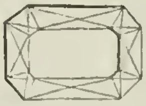
EMBRASURE, in Fortification, a hole or aperture in a parapet, through which the cannon are pointed to fire into the moat or field.

EMBROCATION, in Surgery and Pharmacy, an external remedy, consisting in an irrigation of the part with some proper liquor, as oil, spirits, &c.

EMBROIDERY, a work in gold or silver, or silk thread, wrought by the needle upon cloth, stuffs, or muslin, into various figures. In embroidering stuffs, the work is performed in a kind of loom, because the more the piece is stretched, the easier it is worked. As to muslin, they spread it upon a pattern ready designed, and sometimes, before it is stretched upon the pattern, it is starched, to make it more easy to handle.

EMBRYO, in Physiology, the first rudiments of an animal in the womb, before the several members are distinctly formed; after which period it is denominated a fœtus.

EMERALD, is a well-known gem of pure green colour, somewhat harder than quartz. Its natural form is either rounded, or a short six-sided prism. By the ancients the emerald was in great request, particularly for engraving upon. They are said to have procured it from Ethiopia and Egypt. The most intensely coloured and valuable emeralds that we are acquainted with are brought from Peru. They are found in clefts and veins of granite, and other primitive rocks, and oftentimes grouped with the crystals of quartz, felspar, and mica. The emerald is one of the softest of the precious stones, and is almost exclusively indebted for its value to its charming colour. The brilliant purple of the ruby, the golden yellow of the topaz, the celestial blue of the sapphire, are all pleasing tints; but the green of the emerald is so lovely, that the eye, after glancing over all the others, finds delight in resting upon this. In value it is rated next to the ruby; and when of good colour, is set without foil, and upon a black ground, like brilliant diamonds. Emeralds of inferior lustre are generally set upon a green gold foil. These gems are considered to appear to greatest advantage when table cut, as in the figure, and surrounded by brilliants, the lustre of which forms an agreeable contrast with the quiet hue of the emerald. They are sometimes formed into pear-shaped, ear-drops, but the most valuable stones are generally set in rings. A favourite mode of setting emeralds among the opulent inhabitants of South America, is to make them up to clusters of artificial flowers on gold stems. The largest emerald that has been mentioned, is one said to have been possessed by the inhabitants of the Valley of Manta, in Peru, at the time when the Spaniards first arrived there. It is recorded to have been as big as an ostrich's egg, and to have been worshipped by the Peruvians, under the name of the Goddess or Mother of Emeralds. They brought smaller ones as offerings to it, which the priests distinguished by the appellation of daughters. Many fine emeralds are stated to have formerly been bequeathed to different monasteries on the continent; but the greatest part of them are said to have been sold by the monks, and to have had their



place supplied with coloured glass imitations. These stones are seldom seen of large size, and at the same time entirely free from flaws. The emerald, if heated to a certain degree, assumes a blue colour, but it recovers its own proper tint when cold. When the heat is carried much beyond this it melts into an opaque, coloured mass. The Oriental emerald is a variety of the ruby, of a green colour, and an extremely rare gem.

EMERGENT Year, in Chronology, is the first year of any particular æra.

EMERSION, in Astronomy, is the re-appearance of the sun, moon, or a planet, after having been eclipsed by the interposition of the moon, earth, or other body. This term is sometimes also used to denote the re-appearance of a star, which had been hid in the sun's rays. Emersion is also used to denote the rising of a solid body above a fluid in which it floats.

Minutes or *Scruples* of Emersion, in a lunar eclipse, is the arc of the moon's orbit which she has passed over, from the time she begins to emerge out of the earth's shadow, to the end of the eclipse.

EMERSON, William, a very eccentric man, but an excellent mathematician, born in 1701 at Hurworth, in the county of Durham; had a small paternal estate of about £70 per annum, to which he for some time added the profits of a small day-school; this, however, he afterwards discontinued, and lived upon the income of his estate, and the trifling profits arising from his works, which were very numerous. Emerson died on the 20th May, 1782, in the 81st year of his age.

EMERY, is a very hard mineral of blackish or bluish gray colour, is chiefly found in shapeless masses, and mixed with other minerals. It contains about 80 parts in 100 of alumine, and a small portion of iron, is usually opaque, and about four times as heavy as water. The best emery is brought from the Levant, and chiefly from Naxos, and other islands of the Grecian Archipelago. It is also found in some parts of Spain; and is obtained from a few of the iron mines in our own country. In hardness it is nearly equal to adamantine spar, and this property has rendered it an object of great request in various arts. It is employed by lapidaries in the cutting and polishing of precious stones; by opticians, in smoothing the surface of the finer kinds of glass, preparatory to their being polished; by cutlers, and other manufacturers of iron and steel instruments; by masons, in the polishing of marble; and in their respective businesses, by locksmiths, glaziers, and numerous other artisans. For all these purposes, it is pulverized in large iron mortars, or in steel mills; and the powder, which is rough and sharp, is carefully washed, and sorted into five or six different degrees of fineness, according to the description of work in which it is to be employed.

EMETIC, a medicine which induces vomiting.

Emetic *Tartar*, the old name for tartrite of antimony.

EMINENTIAL Equation, a term used by some authors for a certain assumed equation, which involves in itself several particular equations.

EMOLLIENTS, in Medicine and Pharmacy, such remedies as soften the asperity of the humours, and relax and supple the solids.

EMPIS, in Zöology, a genus of insects belonging to the order diptera, the proboscis of a horny substance, bivalve, reflected under the head and breast, and longer than the thorax. There are five species.

EMULGENT, or Renal Arteries, those which supply the kidneys with blood; being sometimes single, and sometimes double on each side.

EMULSION, a milky-looking fluid, caused by an imperfect combination of oil with water by means of mucilage, gluten, &c. All oily farinaceous seeds, as nuts, almonds, linseed, &c. form an emulsion by trituration with water; yolk of egg, which is a natural compound of oil and albumen, makes a similar emulsion.

ENAMEL Painting, is performed on plates of gold, silver, or copper, with certain metallic or earthy colours, melted by intense heat. Fine enamelling should only be practised on plates of gold. Nor must the plate be made flat; as in that case, the enamel cracks; but in the form of a watch-glass, and not too thick. The plate being well forged, the operation is begun by laying on a coat of white enamel on both sides, which prevents the metal from blistering, and this first layer serves for the ground of the other colours. The plate being prepared, the subject to be painted is drawn with red vitriol, mixed with oil of spike, marking all parts of the design lightly with a pencil. The colours, which are previously ground with water, extremely fine, in a mortar of agate, and mixed with oil of spike, are laid on. The painting is afterwards gently dried over a slow fire to evaporate the oil, and the colours melted to incorporate them with the enamel, making the plate red-hot. Any part of the painting effaced, is passed over again, strengthening the shades and colour, committing it again to the fire; and this is repeated till the work is finished. This painting is employed in miniature.

Enamel possesses all the properties of glass, except its transparency. The basis of enamels is a pure crystal glass or frit, ground together with a fine calx of lead and tin, with the addition of a small proportion of the white salt of tartar. These form the principal ingredients of all enamels, which are made by adding pulverized colours, and thoroughly incorporating the whole in a furnace. Enamels are used to counterfeit or imitate precious stones, as well as for painting; or by enamellers and artists working in gold, silver, and other metals. That used by jewellers is brought chiefly from Venice, or Holland, in cakes.

ENCAUSTIC Painting, was in use among the ancients, who employed wax to give a gloss to the colours, and to preserve them from injury. The art was restored by Count Caylus, in 1753. The wood or cloth, stretched on a frame, is rubbed over with bees' wax, being at the same time held over, or before a fire, at such distance that the wax may gradually melt, while it is rubbed on. It must diffuse itself, penetrate the body, and fill the texture of the cloth, which, when cool, is fit to be used. But to make the colours, which are ground in water, adhere to the wax, the whole surface is first rubbed over with Spanish chalk, or white, the colours are then applied. When the picture is dry, it is put near the fire, by which the wax is melted, and the colours absorbed. They are not liable to fade or change; no damp or corrosive substance can affect them; they have no tendency to crack; and, if by accident they receive injury, they can be easily repaired.

About the year 1787, a Miss Greenland, who acquired some knowledge in this art at Florence, communicated, with the presentation of a painting, her method of proceeding, to the Society of Arts. Her directions are the following:—"Take an ounce of white wax, and the same weight of gum mastich, powdered. Put the wax in a glazed earthen vessel, over a very slow fire; and when it is quite dissolved, strew in the mastich, a little at a time, stirring the wax continually, until the whole quantity of gum is perfectly melted and incorporated; then throw the paste into cold water, and when it is hard take it out of the water, wipe it dry, and beat it in one of Mr. Wedgewood's mortars, observing to pound it first in a linen cloth, to absorb some drops of water that will remain in the paste, and prevent the possibility of reducing it to a powder, which must be so fine as to pass through a thick gauze. It should be pounded in a cold place, and but a little while at a time; as after long beating, the friction will in a degree soften the wax and the gum, and instead of their becoming a powder they will return to a paste.

"Make strong gum-arabic water; and when you paint, take a little of the powder, some colour, and mix them together with the gum water. Light colours require but a small quantity of the powder, but more of it must be put in proportion to the body and darkness of the colours; and to black there should be almost as much of the powder as colour.

"Having mixed the colours, and no more than can be used before they get dry, paint with fair water, as is practised in painting with water colours, a ground on the wood being first painted of some proper colour, prepared in the same manner as is described for the picture; walnut tree and oak are the sorts of wood commonly made use of in Italy for this purpose. The painting should be very highly finished, otherwise, when varnished, the tints will not appear united.

"When the painting is quite dry, with rather a hard brush, passing it one way, varnish it with white wax, which is put into an earthen vessel, and kept melted over a very slow fire till the picture is varnished, taking great care that the wax does not boil. Afterwards hold the picture before the fire, near enough to melt the wax, but not to make it run; and when the varnish is entirely cold and hard, rub it gently with a linen cloth. Should the varnish blister, warm the picture again, very slowly, and the bubbles will subside. When the picture is dirty, it need only be washed with cold water."

The Society considered, that Miss Greenland's method provides against all inconveniences; and the brilliancy of the colours in the picture painted by her, and exhibited to the Society, fully justifies the opinion, that the Art of Painting in Wax, as above described, merited the reward of a gold pallet, which was voted to her on this occasion.

ENCHASING, or Chasing, is the art of enriching and beautifying gold, silver, and other metal work, by some designs or figures represented thereon in low relievo, as on watch cases, cane heads, tweezer cases, &c. This is done by punching or driving out the metal from a figure from that withinside, so as to stand out prominent from the surface of the metal. To understand this delicate business, it should be seen performed by its ingenious artisan.

ENCLOSURE, a fence, wall, or hedge, or other means of protection and security surrounding land. Countries, however, in general, lie open, with nothing but banks and ditches to divide the land of every husbandman; but in England, each separate farm is divided from others by hedges and fences, and the farms themselves are broken into small enclosures. In France, Germany, Italy, Spain, and most other nations, the lands still remain unenclosed in large open fields; and those countries, in consequence, present a dreary appearance to the eye of an Englishman, whose enclosures render England the garden of the world. Enclosures greatly improve the climate of a country, by protecting it from inclement winds; they pleasantly subdivide the labours of the farmer; and by restraining the exercise of cattle, they occasion them to get fat much sooner.

ENDEMIC Diseases, those to which the inhabitants of particular countries are subject more than others.

ENDOWMENT, in Law, denotes the settling a dower on a woman, and sometimes for settling a provision for a church, college, or hospital.

ENFILADE, in the art of war, signifies firing along a trench or other place, and is equivalent to raking a ship. Hence trenches are usually dug in a zig-zag manner, that they may never be enfiladed, or shot along their whole length.

ENFRANCHISEMENT, in Law, the incorporating a person into any society or body politic; such as the enfranchisement of one made a citizen of London, or other city, or burgess of any town corporate, because he is made partaker of its liberties, or franchises.

ENGAGEMENT, in a naval sense, implies a battle at sea, or an action of hostility between single ships, squadrons, or fleets of men of war.

The engagements of the ancients were usually carried on in two different manners. Advanced by their oars, the galleys ran violently aboard of each other, and by the encounter of their beaks and prows, and sometimes of their stems, endeavoured to dash to pieces or sink their enemies. For this purpose the prow was armed with a brazen point or trident, nearly as low as the surface of the water. Some of the galleys were furnished with turrets and buildings, for attack or defence. The soldiers annoyed their enemies with darts, slings, swords, and javelins; and in order that their weapons might be directed with greater force and certainty, the ships were equipped with platforms above the deck. The sides of the ships were fortified with a thick fence of hides, which served to repel the darts of the adversaries, and to cover their own soldiers, who thereby annoyed the enemy with greater security.

As to bore and sink the enemy's ships with the rostra was the chief manner of sea-engagements among the ancients; high and bulky ships had accordingly a great advantage over their adversaries, by the force of the stroke of a large ship. The height was likewise no small convenience in boarding and throwing missile weapons, so that it was much more true among them than among us, that a little ship durst not lay her side to a great one; and though great ships were commonly bad sea-boats, they had a superior force in a sea engagement, the shock of them being sometimes so violent as to throw the crew on the upper deck of smaller ships overboard. This occasioned the ancients gradually to increase the bulk of their ships, till they came at last to an enormous size, and then machines, now unknown, were employed in naval engagements; but the following are a few which we find recorded by the ancient writers:

The *Dolphin* a large massy piece of lead or iron in the form of a dolphin, and suspended by blocks at the mast heads or yardarms, and ready for a proper occasion, was let down violently from thence into the adverse ships, and either penetrated through their bottom, and opened a passage for the entering waters, or by its weight immediately sunk the vessel.

The *Drepanum*, an engine of iron, crooked like a sickle, and fixed in the top of a long pole, cut asunder the slings of the sail yards, and thereby let the sails fall down, to disable the vessel from escaping, and incommode her during the action. Similar to this was another instrument, armed at the head with a broad two-edged blade of iron, to cut away the ropes that fastened the rudder in the vessel There were also spears or maces of an extraordinary length, sometimes exceeding twenty cubits; also certain machines for throwing large stones into the enemy's ships.

Another engine was suspended to the main mast, and resembled a battering-ram, for it consisted of a long beam and a head of iron, and was with great violence pushed against the sides of the enemy's galleys. The grappling iron, which was usually thrown into the adverse ship by means of an engine, facilitated the entrance of the soldiers appointed to board, on wooden bridges, that were generally kept ready for this purpose in the fore part of the vessel.

The arms used by the ancients rendered the disposition of their fleets very different, according to the time, place, and circumstances. They generally considered it an advantage to be to windward, and to have the sun shining directly on the front of their enemy. The order of battle chiefly depended on their power of managing the ships, or of drawing them readily into form; and on the schemes which their officers had concerted. The fleet being composed of rowing vessels, they lowered their sails previous to the action: they presented their prows to the enemy, and advanced against each other by the force of their oars. Before they joined battle, the admirals went from ship to ship, and exhorted their soldiers to behave gallantly. All things being in readiness, the signal was displayed by hanging out of the admiral's galley a gilded shield, or a red garment or banner. During the elevation of this, the action continued, and by its depression or inclination towards the right or left, the rest of the ships were directed how to attack or retreat from their enemies. To this was added the sound of trumpets, which began in the admiral's galley, and continued round the whole fleet. The fight was also begun by the admiral's galley, by grappling, boarding, and endeavouring to overset, sink, or destroy the adversary. Sometimes, for want of grappling irons, they fixed their oars in such a manner as to hinder the enemy from retreating. If they could not manage their oars as dexterously as their antagonist, or fall alongside to board him, they penetrated his vessel with the brazen prow. The vessels approached each other as well as their circumstances would permit, and the soldiers fought hand to hand till the battle was decided; nor indeed could they fight otherwise with any certainty, since the shortest distance rendered their slings and arrows, and almost all their offensive weapons, ineffectual, if not useless. The squadrons were sometimes ranged in two or three lines parallel to each other; being seldom drawn up in one line, unless when formed into a half moon. This order appears the most convenient for rowing vessels that engage by advancing their prows towards the enemy.

The famous machine, called the *Corvus*, was erected on the prow of their vessels, in the shape of a round piece of timber of about a foot and a half diameter, and about twelve feet long; on the top whereof, they had a block or pulley. Round this piece of timber they laid a stage or platform of boards, four feet broad, and about eighteen feet long, which was well framed and fastened with iron. The entrance was long-wise, and it moved about the aforesaid upright piece of timber, as on a spindle, and could be hoisted up within six feet of the top; about this was a sort of a parapet, knee-high, which was defended with upright bars of iron, sharpened at the end; towards the top whereof there was a ring: through this ring, fastening a rope by the help of the pulley, they hoisted or lowered the engine at pleasure, and so with it attacked the enemy's vessels, sometimes on their bow, and sometimes on their broadside. When they had grappled the enemy with those iron spikes, if they happened to swing broadside to broadside, then they entered from all parts; but in case they attacked them on the bow, they entered, two and two, by the help of this machine, the foremost defending the fore part, and those that followed, the flanks; keeping the top of their bucklers level with the top of the parapet.

The Romans were restrained by a treaty with Carthage from sailing beyond the Fair Promontory, &c. but they resolved to contend for the dominion of the sea with the Carthaginians, who had held it uncontested from their ancestors, and began anew by building a whole fleet, after the model of one of their enemy's galleys that was stranded on their coast; and as they never wanted expedients in their military concerns, they placed banks of rowers on board, in the same form as those of the galleys, and instructed their men to strike and recover their oars by a proper signal, till they were so perfect in the exercise, and so expert in the discipline and management of their fleet, (which was improved with the Corvus, for the purpose of boarding, as already described), that they soon defeated their enemies. The two consuls were in the two admirals' galleys, in the front of their two distinct squadrons, each of them just ahead of their own divisions, and abreast of each other: the first division being posted on the right, and the second on the left, making two long files or lines of battle. And when it was necessary to give to each galley a due space to ply their oars and keep clear one of another, and to have their heads or prows looking somewhat outwards; this manner of drawing up did therefore naturally form an angle, the point whereof was at the two admirals' galleys, which was near together; and as their two lines were prolonged, so the distance grew consequently wider and wider towards the rear. And because the naval as well as the land army consisted of four legions, the ships accordingly made four divisions, two of which were behind: of these, the third fleet or the third legion was drawn up frontwise, in the rear of the first and second, and so stretching along from point to point, composed a triangle, whereof the third line was the base. Their vessels of burden that carried their horses, baggage, &c. were in the rear of these, and by the help of small boats provided for that purpose, were towed or drawn after them. In the rear of all was the fourth fleet, called the Triarians, drawn up likewise in rank or frontwise, parallel to the third; but these made a longer line, by which means the extremities stretched beyond the two angles at the base. This was a body of great strength, not easily broken, and excellently disposed for the ships in the rear to succour, relieve, and come in the place of, any that should fail in front.

For the reader's more immediate conception of these preparations, we here annex the order of battle:

○ ○
First Division * * Second Division
* *
* *
* *
* *
Third * * * * * * * * * Division
Vessels of * * * * * Burden
Fourth * * * * * * * * * * * * Division.

At the battle of Ecnomus, between the Romans and Carthaginians, the fleet of the former was thus ranged into a wedge in front, and towards the middle of its depth into two right parallel lines. That of the latter was formed into a rectangle or two sides of a square, of which one branch extended behind, and as the opening of the other prosecuted the attack, was ready to fall upon the flank of such of the Roman galleys as should attempt to break their line. Ancient history has preserved many of these orders, of which some have been followed in later times. Thus, in a battle in 1340, the English fleet was formed in two lines, the first of which contained the larger ships, and the second consisted of all the smaller vessels used as a reserve to support the former wherever necessary. In 1545 the French fleet, under the command of the Mareschal d'Armebault, in an engagement with the English in the Channel, was arranged in the form of a crescent. The whole of it was divided into three bodies, the centre being composed of thirty-six ships, and each of the wings of thirty. He had also many galleys, but these fell not into the line, being designed to attack the enemy occasionally. This last disposition was continued down to the reigns of James I. and Louis XII.

The invention of gunpowder took place in 1330, and the use of fire-arms was gradually introduced into naval war, without finally superseding the ancient method of engagement. The Spaniards were armed with cannon in a sea-fight against the English and the people of Poitou, abreast of Rochelle, in 1372; and this battle is the first in which mention is made of artillery in our navies. Many years elapsed before the marine armaments were sufficiently provided with fire-arms; and in the reign of Charles V. machines were continued in use. So great a revolution in the manner of fighting, and which necessarily introduced a total change in the construction of ships, could not be suddenly effected; but ships are no longer formed of rowing vessels, or composed of galleys, but of ships of the line, which engage under sail, and discharge the whole force of artillery from their sides, being disposed in no other form than that of a right line parallel to the enemy; every ship keeping close hauled upon a wind on the same tack. Indeed, the difference between the force and manner of fighting of ships and galleys rendered their service in the same line incompatible. When we consider, therefore, the change introduced both in the construction and working of ships, occasioned by the use of cannon, it necessarily follows, that squadrons of ships-of-war must appear in the order that is now generally adopted. Finally, the ships ought to present their broadsides to the enemy, and to sail close upon a wind in the wake of each other, as well to retain their own uniformity, as to preserve or acquire the advantage which the weather-gage gives them over their adversary.

Of all the weapons used by the ancients, the pike and the sword are the only ones now remaining, the others having been totally supplanted by those machines which originated with the invention of gunpowder. Our naval engagements are, therefore, almost generally decided by fire-arms, of which there are several kinds, known by the general name of artillery; and the fire-arms of a ship of war are distinguished into *cannon* mounted on carriages, *swivel cannon*, *grenadoes*, and *musquetry*.

The *Swivel* cannon is a small piece of artillery, carrying a shot of half a pound, and fixed in a socket on the top of the ship's side, stern, or bow, and also in her tops. The trunnions of this piece are contained in a sort of iron crotch, whose lower end terminates in a cylindrical pivot resting in the socket, so as to support the weight of the cannon. The socket is bored in a strong piece of oak, reinforced with iron hoops, in order to enable it to sustain the recoil. By means of this frame, which is called the swivel, and an iron handle on its cascabel, the gun may be directed by hand to any object. It is, therefore, very necessary in the tops, particularly when loaded with musket balls, to fire down on the upper decks of the adversary, in action.

The *Grenado*, a little shell, of the same diameter as a four-pound bullet, weighs about two pounds, and is charged with four or five ounces of powder. Grenadoes are thrown from the tops by the hands of the seamen. They have a touch-hole in the same manner as a shell, and a fuse of the same composition. The sailor fires the fuse with a match, and throws the grenado as he is directed; the powder being inflamed, the shell instantly bursts into splinters, that kill or maim whomsoever they reach on the decks of the enemy. As this instrument cannot be thrown by hand above 15 or 16 fathoms, the ship must be rather near, to render it useful in battle. As to the musket or firelock, it is so well known that a description of it would be unnecessary.

Besides these machines, there are several others used in merchant ships and privateers, as carabines, cohorns, fire-arrows, &c.

The *Carabine*, a sort of a musquetoon, the barrel of which is rifled spirally from the breech, so that when the ball, which is forced into it, is again driven out by the strength of the powder, it is lengthened about the breadth of a finger, and marked with the rifle of the bore. This piece has an iron rammer; the barrel, including the stock, is three feet long. It has a much greater range than the musquet; because the rifle of the barrel impedes the ball, which thereby makes the greater resistance at the first inflammation of the powder, and giving time for the whole charge to take fire before it goes out of the bore, it is at length thrown out with greater force than from the common musquet.

The *Cohorn*, a sort of small mortar, fixed by a swivel, and particularly used to discharge grenadoes or cast bullets into merchant vessels, when boarded.

The *Fire arrow*, a small iron dart, furnished with springs and bars, together with a match impregnated with powder and sulphur, which is wound about its shaft, is intended to fire the sails of the enemy, and is, for this purpose, discharged from a musquetoon or swivel-gun. The match, kindled by the explosion, communicates the flame to the sail against which it is directed, where the arrow is fastened by means of its bars and springs. This is peculiar to hot climates, particularly the West Indies; the sails, being extremely dry, are instantly inflamed, and, of course, convey the fire to the masts and rigging, and finally to the vessel itself.

The *Organ*, a machine consisting of six or seven musquet barrels fixed upon one stock, so as to be fired all at once.

A general engagement of fleets or squadrons of ships of war being nothing else than a variety of particular actions of single ships with each other in line of battle, it will be necessary first to describe the latter, and then proceed to represent the usual manner of conducting the former.

The whole economy of a naval engagement may be arranged under the following heads: 1. The preparation; 2. The action; and 3. The repair, or refitting for the purposes of navigation.

The preparation is begun by issuing an order to clear the ship for action, which is repeated by the boatswain and his mates at all the hatchways or staircases leading to the different batteries. In a ship of war, the management of the artillery requiring a number of men, the officers and sailors are consequently restrained to a narrow space in their usual habitations, to preserve the internal regularity of the ship. Accordingly, the hammocks, or hanging beds, of the latter are crowded together as close as possible between the decks, each of them being limited to the breadth of 14 inches, and they are hung parallel to each other, in rows stretching from one side of the ship to the other, nearly throughout her whole length, so as to admit of no passage but by stooping under them. While suspended in this situation, it would be impossible to work the cannon, and therefore they must be removed with the greatest expedition. Accordingly, at the summons of the boatswain, who cries, "Up all hammocks," every sailor repairs to his own, and having stowed his bedding properly, cords it firmly with a lashing or line provided for that purpose, and carries it to the quarter-deck, poop, forecastle, or whatever other place is most convenient. As each side of the quarter-deck and poop is furnished with a double net-work, supported by iron cranes fixed immediately above the gunwale or top of the ship's side, the hammocks thus corded are firmly stowed by the quarter masters between the two parts of the netting, so as to form an excellent barrier. The tops, waist, and forecastle, are then fenced in the same manner. By thus disposing of the hammocks, a double advantage is obtained: the batteries of cannon are immediately cleared of an incumbrance, and the hammocks are converted into a sort of parapet to prevent the execution of small shot on the quarter deck, tops, and forecastle. The hammocks, &c. are not unfrequently thrown overboard at once, when there is no time to stow them away.

During the performance of these offices below, the boatswain and mates are employed in securing the sails and yards, to prevent them from tumbling down when the ship is cannonaded, as she might thereby be disabled and rendered incapable of attack, retreat, or pursuit. The yards are likewise secured by strong chains or ropes, in addition to those by which they are usually suspended. The boatswain also provides the necessary materials to repair the rigging, wherever it may be damaged by the shot of the enemy; and to supply whatever parts of it may be entirely destroyed. The carpenter and his crew, in the mean time, prepare their shot plugs and mauls to close up any dangerous breaches that may be made near the surface of the water, and provide the iron work necessary to refit the chain pumps, in case their machinery should be injured in the engagement. The gunner, with his mates and quarter-gunners, are busied in examining the cannon of the different batteries, to see that their charges are thoroughly dry and fit for execution: to have every thing ready for furnishing the great guns and small arms with powder, as soon as the action begins: and to keep a sufficient number of cartridges continually filled, to supply the place of those expended in battle. The master and his mates are attentive to have the sails properly trimmed, according to the situation of the ship, and to reduce or multiply them, as occasion requires, with all possible expedition. The lieutenants visit the different decks, to see that they are effectually cleared of all incumbrance, so that nothing may retard the execution of the artillery, and to enjoin the other officers to diligence and alertness in making the necessary dispositions for the expected engagement, so that every thing may be in readiness at a moment's warning.

When the hostile ships have approached each other to a competent distance, the drums beat to arms, and the boatswain and his mates pipe "All hands to quarters" at every hatchway. The persons appointed to manage the great guns immediately repair to their respective stations; and crows, handspikes, rammers, sponges, powder-horns, matches, train-tackles, &c. are placed in order by the side of every cannon. The hatches are laid, to prevent any one from escaping into the lower apartments. The marines are drawn up in rank and file on the quarter deck, poop, and forecastle. The lashings of the great guns are let loose, and the tompions withdrawn: the whole artillery above and below is run out at the ports, and levelled to the point-blank range, ready for firing

When these necessary preparations are finished, and the officers and crew are all ready at their respective stations, to obey every occasional order, the commencement of the action is determined by the mutual distance and situation of the adverse ships, or by the signal from the commander in chief of the fleet or squadron. The cannon being levelled in parallel rows, projecting from the ship's side, the most natural order of battle is evidently to range the ships abreast of each other, especially if the engagement is general. The most convenient distance is probably within the point-blank range of a musquet, so that all the artillery may do effectual execution.

The combat usually begins by a vigorous cannonade, accompanied by the united efforts of all the swivel guns and small arms. As the method of firing platoons, volleys, or broadsides of cannon at once is generally found injurious in the sea service, it should seldom be attempted, unless in the battering of a fortification; for the sides and decks of the ship, although sufficiently strong for all the purposes of war, would be too much shaken by so violent an explosion and recoil. Instead thereof, the general practice on this occasion throughout the ship is to load, fire, and sponge the guns with all possible expedition, yet without confusion or precipitation. The captain of each gun is particularly enjoined to fire only when the piece is properly directed to its object, that the shot may not be fruitlessly expended. The lieutenants who command the different batteries, traverse the deck, to see that the battle is prosecuted with vigour, and to exhort and animate the men in their duty. The midshipmen second these injunctions, and give assistance, where it is required, at the guns committed to their charge. The gunner takes care that all the artillery is sufficiently supplied with powder, and that the cartridges are carefully conveyed along the decks in covered boxes.

The havoc produced by a continuation of this mutual assault, as at the Nile, Trafalgar, &c. can be more easily imagined than described; battering, penetrating, and splintering the sides and decks; shattering or dismounting the cannon; mangling and destroying the rigging; cutting asunder or carrying away the masts and yards; piercing and tearing the sails so as to render them useless; and wounding, disabling, or killing the ship's company. The comparative vigour and resolution of the assailants to effect these dreadful consequences, generally determine their success or defeat; but sometimes the fate of the combat may be decided by some unforeseen incident, which may be as fortunate for the one as fatal to the other.

The ship that is defeated acknowledges the victory by striking her colours, and is immediately taken possession of by the conqueror, who secures her officers and crew as prisoners in his own ship, and invests two principal officers with the command of the prize till a captain is appointed by the commander in chief.

When the engagement is concluded, the men begin the repair, or refitting, for the purposes of navigation. Accordingly, the cannon are secured by their breechings and tackles, with all convenient expedition. Whatever sails have been rendered unserviceable are unbent, and the wounded masts and yards struck upon the deck, and repaired, or replaced by others; the standing rigging is knotted, and the running rigging spliced, wherever this is necessary. Proper sails are bent in the room of those which have been removed as useless. The carpenter and his crew are employed in repairing the breaches made in the ship's hull, by shot-plugs, pieces of plank, and sheet lead. The gunner and his assistants are busied in replenishing the allotted number of charged cartridges, to supply the place of those which have been expended, and in refitting whatever furniture of the cannon may have been damaged by the late action.

Such are the usual consequences and process of an engagement between two ships of war, which may be considered as an epitome of a general battle between fleets or squadrons. The latter, however, involves a greater variety of incidents, and necessarily requires more comprehensive skill and judgment in the commanding officer.

When the commander in chief, or admiral of a naval armament, has discovered an enemy's fleet, his principal concern is usually to approach it, and endeavour to come to action as soon as possible. Every inferior consideration must be sacrificed to this important object, and every rule of action should tend to hasten and prepare for so material an event. The state of the wind, and the situation of his adversary, will, in some measure, dictate the conduct necessary to be pursued with regard to the disposition of his ships on this occasion. To facilitate the execution of the admiral's orders, the whole fleet is ranged into three squadrons, each of which is classed into three divisions, under the command of different officers. Before the action begins, the adverse fleets are commonly drawn up in two lines, parallel to each other and close hauled. As soon as the admiral displays the signal for the line of battle, the several divisions separate from the columns, in which they were disposed in the usual order of sailing, and every ship crowds into its station in the wake of the next a-head: a proper distance from each other (which is generally about fifty fathoms) being regularly observed from the van to the rear. The admiral, however, will occasionally contract or extend his line, so as to conform to the length of that of his adversary, whose neglect, or inferior skill in this respect, he will naturally convert to his own advantage, as well as to prevent his own line from being doubled upon; a circumstance which might cause great confusion among his van and rear.

When the adverse fleets approach each other, the courses are commonly hauled up in the brails, and the top-gallant-sails and stay-sails furled. The movement of each ship is chiefly regulated by the main and fore top-sails and the jibs; the mizen-top-sail being reserved to hasten or retard the course of the ship, and, in fine, by filling or backing, hoisting or lowering it, to determine her velocity. The frigates, tenders, and fire-ships, being also hauled upon a wind, lie at some distance, ready to execute the admiral's orders or those of his second's, leaving the line of battle between them and the enemy. If there are any transports or storeships attendant on the fleet, these are disposed at a still farther distance from the scene of action. If the fleet is superior in number to that of the enemy, the admiral usually selects a body of reserve from the different squadrons, which will be always of use to cover the fire-ships, bomb-vessels, &c. and may fall into the line in any case of necessity: these also are stationed at a convenient distance from the line, and should evidently be opposite to the weakest parts thereof.

Order and discipline give additional strength and activity to a fleet. If thus a double advantage is acquired by every fleet, it is certainly more favourable to the inferior, which may thereby change its disposition with greater facility and despatch than one more numerous, yet without being separated. When courage is equal to both, good order is then the only resource of the smaller number. Hence we may infer, that a smaller squadron of ships of war, whose officers are perfectly disciplined in working their ships, may, by its superior dexterity, vanquish a more powerful one, even at the commencement of the engagement; because the latter being less expert in the order of battle, will, by its separation, suffer many of the ships to remain useless, or not sufficiently near to protect each other. Thus, though the Gauls had the advantage of the Romans in their numbers; the Germans in their stature; the Spaniards in their strength and numbers united; the Africans in their artifice and opulence; the Greeks in their policy and prudence; yet the Romans triumphed over all by their discipline.

The signal for a general engagement is usually displayed when the opposite fleets are sufficiently within the range of point-blank shot, so that they may level the artillery with certainty of execution, which is near enough for a line of battle. The action is begun and carried on throughout the fleet in the manner (as described) between single ships, at which time the admiral carries little sail, observing however to regulate his own motions by those of the enemy. The ships of the line meanwhile keep close in their station, none of which should hesitate to advance in their order, although interrupted by the situation of some ship ahead which has negligently fallen astern of her situation.

Such is now the practice of naval war, that the necessary order of battle, and the fabric of our ships, very seldom permit the assault of boarding unless in single actions. No captain ought therefore to abandon his station in the line, under any pretence whatsoever, unless his ship is too much disabled to continue the combat. The small quantity of sail carried on this occasion will permit the bulk of the fleet, although somewhat impaired, to continue their cannonade a long time without quitting the line.

No captain should be induced to break the line through a false ambition to distinguish himself, or with the hope of achieving any distant enterprise, however flattering the prospect may be. He ought to wait the signal of the admiral, or commanding officer; because it is more essential to preserve the regularity of a close line, which constitutes the principal force of the fleet, than to prosecute a particular action, which, although brilliant in itself, has seldom any material consequences, unless his object is to seize a flag-ship, and even this can only be justified by success.

The various exigences of the engagement call forth the skill and resources of the admiral to keep his line as complete as possible, notwithstanding unequal attacks and damage. He must order ships from those in reserve, to supply the place of those which may have been rendered unqualified by the action: he must direct his fire-ships at a convenient time to fall aboard the enemy, and he must detach ships from one part of the line or wing which is stronger, to another which is greatly pressed by superior force, and requires assistance. His vigilance is ever necessary to review the situation of the enemy from van to rear, every motion of whom he should, if possible, anticipate and disappoint. He should seize the favourable moments of occasion, which are rapid in their progress, and never return: an opportunity lost may lose the victory. Far from being disconcerted by any unforeseen incident, however distressing it may be, he should endeavour to overcome all difficulties, and make them, if possible, subservient to his designs. His experience and reflection will naturally furnish him with every method of intelligence to discover the state of his different squadrons and divisions. Signals of inquiry and answers—of request and assent—of command and obedience—must be displayed and repeated on this occasion. (*See* the article

SIGNAL.) Tenders and boats must also be continually detached between the admiral and the commanders of the several squadrons or divisions.

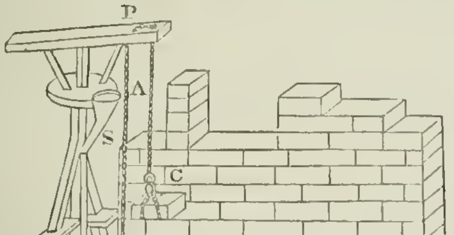
When danger presses, he should be fortified by resolution and presence of mind, because the whole fleet is committed to his charge, and the conduct of his officers may, in a great degree, be influenced by his intrepidity and perseverance. In short, his fame or infamy may depend upon the fate of a day.

If he proves victorious, he should prosecute that victory as much as possible, by seizing, burning, or otherwise destroying the enemy's ships. If he is defeated, he should endeavour, by every resource his experience can suggest, to save as many of his fleet as possible, by employing his tenders, &c. to take out the wounded, and put fresh men in their places, by towing the disabled ships to a competent distance, and by preventing the execution of the enemy's fire-ships. In order to retreat with more security, he may judge it expedient to range his fleet into the form of a half-moon or crescent, placing himself in the centre. By this disposition, the enemy's ships which attempt to fall upon his rear, will at once expose themselves to the fire of the admiral and his seconds, in an advantageous situation: a circumstance which will serve to facilitate the escape of his own ships, and retard the pursuit of those of his adversary. Should his fleet be too much extended by this arrangement, the wings, or quarters, are easily closed, and the half-moon rendered more complete; in the midst of which may be placed his store-ships, tenders, &c. In retreating, the uncertainty of the weather is to be considered: it may become calm, or the wind may shift in his favour. His schemes may be assisted by the approach of night, or the proximity of land, and he ought rather to run the ships ashore, if practicable, than suffer them to be taken afloat, and thereby transfer additional strength to the enemy. In short, nothing should be neglected that may contribute to the preservation of his fleet, or prevent any part of it from falling into the hands of the conqueror.

Upon the whole it appears, the real force or superiority of a fleet consists less in the number of vessels and the vivacity of the action, than in good order, dexterity in working the ships, presence of mind, and skilful conduct in the admiral and captains.

ENGINE, in Mechanics, a compound machine formed of one or more of the mechanical powers, and in our language implies nearly the same as machine. Commonly the most simple mechanical powers are denominated *tools* or *instruments*, the simplest combination of these are called *machines*, and the more complicated and powerful are denominated *engines*.

ENGINE *to let down heavy weights*, as stones, timber, &c. when taking down old buildings, &c. as in the following figure.



Erect a frame of wood, or set up a gin close to the wall, and let the pulley P be firmly attached to the frame. A cord passes over this pulley, one end of which, C, has a hook, to which the stone, &c. can readily be fastened; the other end, D, carries a vessel which may be filled with water from the reservoir M, on the ground at the bottom of the wall. Then while one man is fixing the stone to the hook at the top of the wall, let another put water into the vessel at the bottom, till it nearly equals the weight of the stone; after which, leaving both to the free operation of gravity, or retarding the motion if requisite, the stone may be thus gradually lowered, while the vessel, a cask for instance, will be raised to the funnel A, into which the water may be poured, and thence conveyed by a wooden or a leather pipe to the reservoir M. Then the vessel D may be suffered to descend, and the hook C will be raised, to be fixed to another stone; and thus the operation may be repeated as often as is necessary.

The same method may likewise be adopted in lowering sacks from a high granary, or packages from an upper warehouse. The velocity of the descending weight may be so regulated as to have any proportion to that which gravity imparts to bodies falling freely; thus, if W denote the weight to be lowered, V that of the vessel of water, we shall have $\frac{W - V}{W + V}$, for the fraction expressing the ratio of the velocity to that freely imparted by gravity when denoted by unity. Thus, if $V = \frac{1}{2}W$, the weight will fall through $\frac{1}{3}$ of $16\frac{1}{12}$, or about $5\frac{1}{3}$ feet in the first second; if $V = \frac{2}{3}W$, the weight will fall through $\frac{1}{5}$ of $16\frac{1}{12}$, or about $3\frac{1}{5}$ feet in the first second; the friction of the pulley being in both instances disregarded.

ENGINEER, a person employed in the construction of the larger kind of engines, or in the application of them to particular purposes.

ENGINEER, is also commonly applied to an officer who is appointed to inspect and contrive any attacks, defences, &c. of a fortified place, or to build or repair them, &c.

ENGRAFTING, *see* GRAFTING.

ENGRAILED, in Heraldry, signifies a thing on which the hail has fallen and broken off its edges, leaving them ragged, or with half rounds, or semicircles struck out of their edges.

ENGRAVING, is the cutting of lines upon a copperplate, by means of a steel instrument, called a graver, without the use of aqua-fortis. This, the first way of producing copperplate prints that was practised, is still used in historical subjects, portraits, and in finishing landscapes. The necessary tools are, gravers, a scraper, a burnisher, an oil stone, a sand bag, an oil rubber, and good charcoal. The gravers are steel tempered instruments, fitted in a short wooden handle. They are of either a square or lozenge form; the first for cutting broad strokes, the other for fainter and more delicate lines. The scraper, a three-edged tool for scraping off the burr raised by the graver. Burnishers are for rubbing down lines that have been cut too deep, or burnishing out scratches or holes in the copper: they are made of hard steel, well rounded and polished. With the oil stone, the gravers, etching points, &c. are whetted. Upon the sand bag, or cushion, the plate is laid, for the convenience of turning it round in any direction. The oil rubber and charcoal are used for polishing the plate when necessary. Great care is required to whet the graver nicely, particularly its belly; the two angles of the graver which are to be held next the plate must be laid flat upon the stone, and rubbed steadily, till the belly rises gradually above the plate, so that when you lay the graver flat upon it, you may just perceive the light under the point, else it will dig into the copper, and you cannot keep a point, or execute the work with freedom. In order to this, your right arm must be kept close to your side, the forefinger of your left hand placed upon that part of the graver which lies uppermost on the stone. To whet the face, place the flat part of the handle in the hollow of your hand, with the belly of the graver upwards, upon a moderate slope, and rub the extremity, or face, upon the stone, till it has an exceeding sharp point, which you may prove by trial upon your thumb nail.

When the graver is too hard, as is usually the case when first bought, and may be known by the frequent breaking of the point, the method of *tempering* it is as follows:—heat a poker red-hot, and hold the graver upon it, within half an inch of the point, till the steel changes to a light straw-colour; then put the point into oil to cool, or hold the graver close to the flame of a candle, till it be of the same colour, and cool it in the tallow, but be careful either way not to hold it too long, else it will be too soft; in this case the point, which will then turn blue, must be tempered again. Be not hasty in tempering, for sometimes little wetting will bring it to a good condition, when it is but little too hard.

To hold the graver, cut off that part of the handle upon the same lines with its belly, or sharp edge, making that side flat, that it may be no obstruction. Hold the handle in the hollow of your hand, extend your forefinger towards the point, let it rest on the back of the graver, that you may guide it flat and parallel with the plate. Let not your fingers interpose between the plate and the graver, else they will hinder you from carrying the graver level with the plate, and from cutting the strokes clearly.

To lay the design upon the plate, after you have polished it fine and smooth, heat it till it will melt virgin wax, with which rub it thinly and equally over, and let it cool. Then, with a black-lead pencil, draw on paper the design which you mean to engrave, lay it upon the plate, with its pencilled side upon the wax, then press it close, and with a burnisher go over every part of the design, and when you take off the paper, you will find every line which you drew with the black-lead pencil upon the waxed plate, as if it had been drawn; then with a sharp-pointed tool trace all your design through the wax upon the plate, and you may then take off the wax, and proceed to engrave. The table, or board you work at, should be firm and steady; your plate should rest upon the sand bag; and holding the graver as above directed, proceed according to the following rules:—For straight strokes, hold your plate firm upon the sand bag with your left hand, move your right hand forwards, leaning lighter where the stroke should be fine, and harder where you would have it broader; but for circular lines, hold the graver steadfast, and move your hand or the plate as you see convenient. Learn also to carry your hand with such dexterity, that you may finish your stroke as finely as you began it; if you are to make one part deeper or blacker than another, do it by degrees; and that you may do it with exactness, take care that your strokes be neither too close nor too wide. Scrape off the roughness in the course of your work, but do not scratch the plate; and to see how your work goes on, rub the plate with oil rubber, and wipe it clean. The glare of the fresh-cut copper will thus be taken off, and you will see to better advantage what you have been doing. Mistakes and scratches are rubbed out with the burnisher, the part levelled with the scraper, and the work proceeded in as formerly. In shading up your work, commence with the fainter lines, and finish with deeper. The dry-point executes the lightest parts of the work, as the water, sky, fine draperies, &c. To prevent too much light, a sash made of transparent paper should be placed between your work and the light, which will greatly assist your eyes when the sun shines fiercely.

Engraving on Wood, Glass, &c.—Engraving on wood is a process exactly the reverse to engraving on copper. In copper, the strokes to be printed are sunk or cut into the copper, and a rolling press is used for printing it; in engravings on wood, on the contrary, all the wood is cut away, except the lines to be printed, which are left standing. A wood cut is a type, and the mode of printing is the same as that used in letter-press. Box-wood, planed quite smooth, is used for this purpose. The design is then drawn upon the wood itself with a black-lead pencil; all the wood is then cut away with gravers and other tools, except the lines that are drawn. Or, the design is sometimes drawn upon paper, and pasted upon the wood, which is cut as before.

This art is of considerable difficulty; there are now many who practise it, but few who have attained excellence; Bewick, Branston, Hughes, and some others, cut most beautifully. It is, however, useful for books, not because the printing of it is cheaper, as has been supposed, than that of copperplates; but because a block for ready reference can be put in where an engraving on copper could not. Yet it cannot be applied equally well to all the purposes to which copperplate engraving is applicable.

Etching on Glass.—Glass resists the action of all acids, except the fluoric acid. By this, however, it is corroded as copper is by aqua-fortis; and plates of glass may be engraved in the same manner as copper. There are several methods of performing this. We shall first describe the process of etching by the fluoric acid in the *state of gas*. Having covered over the glass to be etched with a thin coat of virgin wax, (common bees' wax bleached white,) draw the design upon it, in the same manner as in etching on copper. Take some *fluor spar*, (Derbyshire spar,) pound it fine, put it into a leaden vessel, and pour some sulphuric acid over it; place the glass with the etched side lowermost over this vessel, two or three inches above. Apply to the leaden vessel a gentle heat, which will cause the acid to act upon the fluor spar, and the gas disengaging itself will corrode the glass. When it is sufficiently corroded, the wax may be removed by oil of turpentine. This etching may be also performed by raising a margin of bordering wax round the glass, as on copper, and pour on the liquid fluoric acid, which acts upon the glass.

A third method of etching on glass is as follows:—Having put the wax on the glass, draw your design upon it: raise a margin all round it. Then put pounded fluor spar with some sulphuric acid, diluted with water, upon the glass. The sulphuric acid will disengage the fluoric, which being absorbed by the water, will corrode the glass. Beautiful ornaments may thus be etched on glass, and applied to decorate windows, by painting the figure of the ornament on panes of glass with engravers' stopping varnish, and then exposing the panes to the action of the gas. The gas will corrode all the surface of the glass, except where the varnish has been put, and give it the appearance of ground glass, which may be rendered more or less opaque by lengthening or shortening the process. The parts where the varnish was applied, will continue transparent, and seem extremely bright. It is to be noticed, that when liquid fluoric acid is used, that lines which have been etched continue still transparent; but when the gas has been employed, the line is white and opaque, as if cut by a wheel.

Engraving on Precious Stones.—In engraving *diamonds*, the first thing is to cement two rough diamonds to the ends of two sticks, held steadily in the hand, and rub or grind them against each other, till they are brought into form. The powder serves to polish them, which is performed with a mill turning an iron wheel. The diamond is fixed in a brass dish, and applied to the wheel, and covered with diamond dust, mixed with olive-oil, and first one face, then another, is applied to the wheel. *Rubies*, *sapphires*, and *topazes*, are cut and formed on a copper wheel, and polished with tripoli diluted in water. *Agates*, *amethysts*, *emeralds*, *rubies*, and the softer stones, are cut on a leaden wheel, moistened with emery and water, and polished with tripoli, on a pewter wheel. *Lapis-lazuli*, *opal*, &c. are polished on a wooden wheel. To fashion and engrave vases of agate, crystal, &c. a lathe is used, on which are the tools, turned by a wheel; and the vessel is held to them to be engraven, either in relievo or otherwise; the tools being moistened, from time to time, with diamond dust and oil, or emery and water.

Engraving on Steel, or Dye-sinking.—This is chiefly used in cutting seals, punches, matrices, and dies for striking coins or medals. The method of engraving with the instruments, &c. is the same for coins as for medals and counters: the only difference is in the relievo, that of coins being less than that of medals, and that of counters less than that of coins. Engravers in steel commonly begin with punches, which are in relievo, and serve for making the creux, or cavity, of the matrices and dies: though sometimes they begin with the creux, but only when the work is to be cut very shallow.

Improvements in Engraving and Copper-plate Printing.—Very extraordinary improvements in the art of producing and multiplying impressions of engravings, have lately been made by Jacob Perkins, of Philadelphia, who, from his pre-eminent skill, was employed by the American Banks in the fabrication of notes. It is the peculiar merit of Mr. Perkins's notes, that they are capable of exhibiting the highest perfection of the art of engraving; while at the same time every impression, though millions of them may be required, is equal to a proof. His mode of proceeding is as follows: He first causes the subject to be engraved on a flat plate of soft steel, which, being duly hardened, is then capable of impressing a similar surface of soft steel in a cylindrical form. The cylinder in its turn being hardened, is then capable of impressing other flat plates of soft steel, or copper-plates; and one cylinder can thus multiply steel or copper plates, in any desirable number, equal in effect and delicacy to the first engraving. From these, of course, any number of impressions on paper may be taken, all fac similes of one another; and, if steel plates are used, they are all equal to proofs; or, if copper, they may be renewed as often as they begin to wear. The apparatus for transferring the impressions, as well as for producing endless lines in beautiful scrolls, and for other purposes, are highly creditable to the genius and manufactures of the United States: but Mr. P. has proved his fertility of contrivance, by inventing a machine for copper-plate printing, by which he is enabled, with 36 plates and the labour of four men, to produce 180 impressions in a minute, or 60,000 in a day. This artist now carries on his business in Fleet-street, London.

ENNEADECATERIS, in Chronology, a cycle or period of 19 solar or lunar years.

ENNEANDICA, in Botany, the name of the 9th class in Linnæus' sexual system, consisting of such plants as have hermaphrodite flowers, with nine stamina, or small organs.

ENSIGN, a large flag or banner, hoisted on a long pole, erected over the stern, and called the ensign-staff; the ensign is used to distinguish the ships of different nations from each other, as also to characterize the different squadrons of the navy: it was formerly written ANCIENT.

ENTABLATURE, or ENTABLEMENT, in Architecture, is that part of an order of a column over the capital, and comprehends the architrave, frieze, and corniche. It is used sometimes to denote the last row of stones on the top of the wall of a building, on which the timber and covering rest.

ENTAIL, in Law, is a fee-estate entailed, that is, abridged and limited to certain conditions prescribed by the donor or granter.

ENTERING PORTS, ports cut down on the middle gun-deck of three-deckers, to serve as doors for persons going in or out of the ship. *Entering Ropes*, or *Side Ropes*, three ropes hanging from the upper part of the ship's side, or from the entering ports, on the right, left, and middle of the steps.

ENTOMOLOGY, that part of Zöology which treats exclusively of insects. Linnæus has divided insects into seven orders. The sexes of insects are commonly two, male and female. Neuters are to be met with among those insects which live in swarms, such as ants, bees, &c. The majority of insects are observed to be annual, finishing the whole term of their lives in the space of a year or less, and many do not live half that time; nay, there are some which do not survive many hours; but this latter period is to be understood only of the animals when in their complete or ultimate form, for the larvæ of such as are of this short duration have in reality lived a very long time under water, of which they are natives; and it is observed, that water insects, in general, are of longer duration than land insects.

Insects are distinguished from other animals by their being furnished with never fewer than six feet, and sometimes with many more; by their breathing, by spiracles or breathing-holes, situated at certain distances along each side of the body; and lastly, by the head being furnished with a pair of *antennæ*, or jointed horns, which are extremely various in the different tribes.

The first state in which the generality of insects appear, is that of an *egg*. From this is hatched the animal in its second state, when it is improperly called the *caterpillar*. The insect, in this state, is the *larva* or larve, a mask or disguise of the animal in its future form. The larve differs in its appearance, according to the tribe to which it belongs. When the time arrives for the larve to change into its next state of *chrysalis*, or *pupa*, it ceases to feed, and having placed itself in some quiet situation for the purpose, lies still for several hours; and then by a laborious effort, frequently repeated, divests itself of its external skin, or larve-coat, and immediately appears in the very different form of a pupa. The Linnæan term *pupa* was given, from the indistinct resemblance which many insects bear in this state to a doll, or a child when swathed up according to the old fashion. The pupa emerges at length the complete insect, in its perfect or ultimate form, from which it can never after change, nor can it receive any further increase of growth. This last or perfect state is termed the *imago*.

Some insects undergo a change of shape, but are hatched complete in all their parts from the egg, and only cast their skin from time to time, during their growth, till they acquire the full size of their species. The *mouth* in some tribes is formed for gnawing the food, and operates by a pair of strong horny jaws, moving laterally, as in the beetle tribe; while in others it is formed for suction, and consists of a sort of tube In the butterfly and moth tribe, it consists of a double tube, which, when at rest, is rolled into a spiral form, and when in use, extended at full length. The *eyes* differ in the different tribes; the greater number of insects are furnished with eyes apparently two in number, and situated on each side the head. The outward surface of the coats of these eyes may be compared to so many convex lenses or glasses. The head of the common dragon-fly is furnished with 25,000 of these lenses! In *spiders*, the eyes are from six to eight in number; of a simple structure, and placed at a considerable distance from each other.

The *muscles*, or organs constituting the several portions of the flesh in insects, are more numerous than in the larger animals, and extremely irritable. In the human body, the muscles scarcely exceed 500, in a large caterpillar more than 4000 have been discovered. The power of the muscles is also much greater than in animals. A flea is capable of springing 200 times its own length; whereas the jerboe or kangaroo, in their most powerful leaps, fall very short of the same proportional distance.

The orders of insects are, 1. *Coleoptera*, which have crustaceous cases covering their wings, and which, when closed, form a longitudinal division along the middle of the back, as in the *cock-chafer*; 2. *Hemiptera*, which have four wings, the upper ones partly crustaceous and partly membranaceous, and being crossed over the back, or incumbent on each other, as the *cock-roach*; 3. *Lepidoptera*, insects with four wings, covered with fine scales and powder, as the *butterfly*, *moth*; 4. *Neuroptera*, having four membranous and semi-transparent wings, veined like network, and the tail with a sting, as the *dragon fly*; 5. *Hymenoptera*, insects which have four membranaceous and semi-transparent wings veined like network, and the tail armed with a sting, as in the *wasp* and *bee*; 6. *Diptera* insects have only two wings, as the *common house-flies*; 7. *Aptera* insects have no wings, as the *spiders*.

ENTRANCE, a name frequently given to the foremost part of the ship under the surface of the sea.

ENTREPAS, in the Manege, the broken pace of a horse, resembling an amble, being neither walk nor trot, and proceeds from the animal having no reins or back, and going upon its shoulders. In general, this is the gait of all horses whose limbs are spoiled.

ENTROCHUS, in Natural History, a genus of extraneous fossils, known by the popular name of St. Cuthbert's beads, usually found in limestone, and of all sizes, from a pin's head to a finger's length.

ENTRY, WRIT OF, is a writ directed to the sheriff, requiring him to command the tenant of the land, that he render to the demandant the premises in question, or appear in court on such a day, and shew why he has not done it.

ENUMERATION, the act of numbering or counting.

ENVELOPE, in Fortification, a work of earth sometimes in form of a simple parapet, and yet at others like a small rampart, with a parapet: it is raised sometimes on the ditch, and sometimes beyond it.

ENVOY, a person deputed to negotiate some affair with any foreign prince or state. Those sent from the courts of France, Britain, &c. to any petty prince of Germany, the republics of Venice, Genoa, &c. go in quality of envoys, not ambassadors; and such a character only do those persons bear, who go from any of the principal courts of Europe to another, when the affair they go upon is not very solemn or important.

EPACTS, (from ϵπαγω, *induco*, *intercalo*,) in Chronology, the excesses of the solar month above the lunar synodical month, and of the solar year above the lunar year of twelve synodical months; or of several solar months above as many synodical months, and several solar years above as many dozen of synodical months. The epacts then are either annual or menstrual.

Menstrual Epacts, are the excesses of the civil or calendar month above the lunar month. Suppose, *e.g.* it were new moon on the first day of January; since the lunar month is $29^{d}\ 12^{h}\ 44'\ 3''$, and the month of January contains 31 days, the menstrual epact is $1^{d}\ 11^{h}\ 15'\ 57''$.

Annual Epacts, are the excesses of the solar year above the lunar. Hence, as the Julian solar year is $365^{d}\ 6^{h}$, and the Julian lunar year $354^{d}\ 8^{h}\ 48'\ 38''$, the annual epact will be $10^{d}\ 21^{h}\ 11'\ 22''$, that is, nearly 11 days. Consequently, the epact of two years is 22 days; of three years, 33 days; or rather thirty, since 30 days make an embolismic, or intercalary month. Thus the epact of four years is 14 days, and so of the rest; and thus every 19th year the epact becomes 30 or 0; consequently the 20th year the epact is 11 again; and so the cycle of epacts expires with the golden number, or lunar cycle of 19 years begins with the same; these are Julian epacts: the Gregorian depend upon the same principles, accounting only for the difference of the respective years.

As the new moons are the same, that is, as they fall on the same day every 19 years, so the difference between the lunar and solar years is the same every 19 years. And because the said difference is always to be added to the lunar year, in order to adjust or make it equal to the solar year, therefore the said difference respectively belonging to each year of the moon's cycle, is called the epact of the said year, that is, the number to be added to the same year, to make it equal to the solar year.

Rule to find the Gregorian Epact.—The difference between the Julian and Gregorian years being equal to the difference between the solar and lunar year, or 11 days; therefore, the Gregorian Epact for any year is the same with the Julian Epact for the preceding year; and hence the Gregorian Epact will be found by subtracting 1 from the golden number, multiplying the remainder by 11, and rejecting the 30's. This rule will serve till the year 1900, but after that year the Gregorian Epact will be found by this rule: divide the centuries of the given year by 4, multiply the remainder by 17; then to this product add 43 times the quotient, and also the number 86, and divide the whole sum by 25, reserving the quotient: next multiply the golden number by 11. and from the product subtract the reserved quotient, so shall the remainder, after rejecting all the 30's contained in it, be the epact sought. The following table contains the golden numbers, with their corresponding epacts, till the year 1900.

Table *of Gregorian Epacts.*

Golden Number.	Epacts.	Golden Number.	Epacts.	Golden Number.	Epacts.
I.	0	VIII.	17	XV.	4
II.	11	IX.	28	XVI.	15
III.	22	X.	9	XVII.	26
IV.	3	XI.	20	XVIII.	7
V.	14	XII.	1	XIX.	18
VI.	25	XIII.	12	I.	0
VII.	6	XIV.	23		

EPHA, or Ephah, in Jewish antiquity, a dry measure containing about a bushel.

EPHEMERA, *the Day-Fly*, or *May-Fly*, a genus of insects belonging to the order of neuroptera. There are eleven species. These flies take their name of May-fly from the shortness of their life. Some live several days, others do not take flight till the setting of the sun, and live not to see his rising. Some exist an hour, others half that time.

EPHEMERIDES, in Astronomy, tables calculated by astronomers, shewing the present state of the heavens for every day at noon; that is, the places wherein all the planets are found at that time. It is from these tables that the eclipses, conjunctions, and aspects of the planets are determined, horoscopes or celestial schemes constructed, &c. The astronomers of most nations publish ephemerides; of these the most celebrated are, the Ephemerides of Bologna; the Nautical Almanac, published in England; and the Connoissance des Temps, published in France.

EPHEMERIS, a Nautical Almanack.

EPICUREANS, a sect of ancient philosophers who followed the doctrine of Epicurus, a celebrated philosopher of Gargetium in Attica, about 300 years before Christ. At the early age of 12 years he gave astonishing proofs of genius, which he afterwards improved by visiting Athens, which was then crowded by the followers of Plato, the Cynics, Peripatetics, and the Stoics. Here he established himself, and soon attracted a number of followers by the sweetness and gravity of his manners, and by his social virtues. In his ethics he maintained that the supreme good of man consists in pleasure, and supreme evil in pain. Nature herself, says he, teaches us this truth; and prompts us from our birth to procure whatever gives us pleasure, and avoid whatever gives us pain. This doctrine, which seemed to open the way to sensuality and dissipation, procured for Epicurus a great number of enemies, particularly amongst the Stoics; but he refuted all the accusations of his adversaries by the purity of his morals. His followers were numerous in every age and country; but they soon degenerated from the comparatively pure sentiments of their master, and placed their happiness in gross and sensual pleasures.

EPICYCLE, in the ancient Astronomy, was a subordinate orbit or circle, which was supposed to move on the circumference of a larger one, called the *different;* by means of which one motion, apparently irregular, was resolved into two that were circular and uniform. And when the observed motion was so irregular and complicated as not to be resolved with one epicycle, others were added till a nearer approximation was obtained. This system owed its origin to a prejudice that seems to have been extremely ancient, in favour of circular motion; and the problem that principally engaged the attention of astronomers in those times, was to assign the proper proportion of the different and epicycle which should approximate nearest to absolute observation.

EPICYCLOID, in Geometry, is a curve generated by a point in one circle, which revolves about another circle, either on the concavity or convexity of its circumference, and thus differs from the common cycloid, which is generated by the revolution of a circle along a right line; though the latter has sometimes been assimilated with the former, by considering the right line as the circumference of a circle whose diameter is infinite. The invention of epicycloids is ascribed to M. Roemer, the celebrated Danish astronomer.

EPIDEMIC, in Medicine, denotes those diseases which prevail at particular seasons, attacking many persons at the same time.

EPIDENDRUM, a genus of the diandria order.

EPIGASTRIC REGION, a part, or subdivision of the abdomen.

EPIGRAPHE, denotes the inscription of a building, pointing out the time when, the persons by whom, and the uses for which it was erected.

EPILEPSY, in Medicine, the same with what is usually called the *falling sickness,* from the patient's falling suddenly on the ground.

EPIPHANY, a Festival, otherwise called the Manifestation of Christ to the Gentiles, observed on the 6th of January, in honour of the appearance of our Saviour to the three magi, or wise men, who came to adore him, and bring him presents. The kings of England and Spain offer gold, frankincense, and myrrh, on epiphany, or twelfth day, in memory of the offerings of the wise men to the infant Jesus. The festival of epiphany is called by the Greeks the Feast of Lights, because our Saviour is said to have been baptized on this day; the baptism is by them called illumination.

EPISCOPACY, ecclesiastical government by bishops and other dignitaries, as in the church of England.

EPISTILE, in Architecture, the architrave, a massive piece of wood or stone laid immediately over the capital of a column.

EPITAPH, a monumental inscription in honour or memory of a person defunct, or an inscription engraven or cut on a tomb, to mark the time of a person's decease, his name, family, and, usually, some eulogium of his virtues, or good qualities.

EPITHEN, in Pharmacy, a kind of fomentation, or remedy of a spirituous or aromatic composition, applied externally to the region of the heart, the liver, &c. to strengthen and comfort the same, or to correct some intemperature thereof.

EPOCHA, or Æra, is a certain fixed point of time, made famous by some remarkable event; from whence, as from a root, the ensuing years are numbered or computed. As there is no astronomical consideration to render one epocha preferable to another, their constitution is purely arbitrary, and therefore various epochas have been used at different times, and among different nations.

The *Christian Epocha* commences on the 25th of December, or the 1st of January. But in those countries which observe the Julian calendar, it commences on the 25th of March. The author of this way of computing from Christ, was Dionysius Exiguus, a Roman abbot, who lived about the beginning of the sixth century.

The *Epocha of the Creation*, according to the Jewish computation, is the year of the Julian period 953, answering to the year of Christ 3761, and commencing on the 7th of October. Hence, if we subtract 952 from any given year of the Julian period, the remainder is the corresponding year of the Jewish epocha of the creation.

The *Epocha of the Olympiads*, used principally by the Greeks, is famous in ancient history. It took its rise from the Olympic games, which were celebrated at the beginning of every fifth year, near Olympia, a city of Elis, in Peloponnesus. An Olympiad, therefore, was a period of four years; and by these periods the Greeks reckoned their time, the year in which the games were celebrated the first year of the Olympiad. The beginning of the first Olympiad is referred to the year of the Julian period 3931, or 776 years before Christ.

The *Epocha of the Building of Rome*, was the principal one among the Romans. This epocha is the year of the Julian period 3961, and answers to the year 752 before Christ, commencing on the 21st of April.

The *Dioclesian Epocha*, or epocha of the Martyrs, commences in the year of Christ 284, and that of the Julian period 4997. It obtained its name from the great number of Christians who suffered martyrdom in the reign of the emperor Dioclesian.

The *Epocha of the Hegira* is used by the Turks, Arabs, and others who profess the Mahometan faith. It commences on the 16th of July, in the year of Christ 622, and of the Julian period 5335. The word *hegira* signifies *flight*; the event which gave occasion to this epocha, being Mahomet's flight from Mecca. The magistrates of that city, finding that his imposture tended to disturb the public peace, were determined to cut off the author of it, to prevent the further spreading of the mischief. But Mahomet, having timely notice of their design, fled by night to Medina, another city of Arabia, in the year of our Lord above mentioned; and this is the principal æra from which the Mahometans compute their time.

Dionysius began his account from the conception or incarnation, usually called the Annunciation, or Lady Day, which method obtained in the dominions of Great Britain till the year 1752, before which time the Dionysian was the same as the English epoch; but in that year the Gregorian calendar having been admitted by act of parliament, we now reckon from the 1st of January, as in the other parts of Europe, except in the court of Rome, where the epoch of the incarnation still obtains for the date of their bulls. The true birth of Christ was four years earlier than is reckoned in the common date, which corresponds to 4709 of the Julian epoch.

EPROUVETTE, the name of an instrument for ascertaining the strength of fired gunpowder, or of comparing the strength of different kinds of gunpowder. One of the best for the proof of powder in artillery, is that contrived by Dr. Hutton. It consists of a small brass gun, about 2½ feet long, suspended by a metallic stem or rod, turning by an axis on a firm and strong frame, by means of which the piece oscillates in a circular arch. A little below the axis, the stem divides into two branches, reaching down to the gun, to which the lower ends of the branches are fixed, the one near the muzzle, the other near the breech of the piece. The upper end of the stem is firmly attached to the axis, which turns very freely by its extremities in the sockets of the supporting frame, by which means the gun and stem vibrate together in a vertical plane, with a very small degree of friction. The piece is charged with a small quantity of powder (usually about two ounces) without any ball, and then fired; by the force of the explosion, the piece is made to recoil or vibrate, describing an arch or angle, which will be greater or less, according to the quantity or strength of the powder.

To measure the quantity of recoil, and consequently the strength of the powder, a circular brazen or silvered arch of a convenient extent, and of a radius equal to its distance below the axis, is fixed against the descending two branches of the stem, and graduated into divisions, according to the purpose required to be answered by the machine, *viz.* 1. Into equal parts, or *degrees*, for the purpose of determining the angle actually described in the vibration. 2. Into unequal parts, according to the *chords*, being in fact 100 times the double sines of the half angles, and running up to 100, as equivalent to 90 degrees; these serve to compare the velocities given by the powder. 3. Into equal parts, according to the versed sines; they are, in truth, 100 times the versed sines of our common tables, 161½ corresponding with 90 degrees, and these serve to compare the forces. The divisions on these scales are read off, that is, marked out, by an index, which is carried on the arch during the oscillation, and then stopping there, shews the actual extent of the vibration. Dr. Gregory has found, upon several trials, that two ounces of powder give 36 on the chords, or 21° on the arc. *Ramsden's* eprouvette is a gun that recoils in a direction parallel to itself, instead of vibrating as a pendulum.

EPSOM SALTS, are sulphate of magnesia.

EQUABLE Motion, is that whereby the moveable body proceeds with the same continued velocity, being neither accelerated nor retarded.

EQUABLY *accelerated* or *retarded Motion*, &c. is when the motion or change is increased or decreased by equal quantities or degrees, in equal times.

EQUAL, a term of relation between two or more things of the same magnitude, quantity, or quality, or equals, are those things which may be substituted for each other without any alteration of their quantity. For it is an axiom in geometry, that two things which are equal to the same thing, are also equal to each other. And again, if to or from equals you add or subtract equals, the sum or remainder will be equal.

Equal *Altitudes*, in Practical Astronomy, one of the most practicable and certain methods of determining the time, and thus ascertaining the error of a clock or chronometer, is by observing equal altitudes of the sun or of a fixed star. For this purpose, all that is necessary is, to observe the instant the sun or star is at any altitude towards the east, before the meridian passage; and the instant must likewise be marked when the same object attains exactly the same altitude towards the west, after the meridian passage; the mean between the above quantities will be the instant marked by the clock at the moment the sun or star was on the meridian. The preceding operation, however, supposes that the declination of the object has not varied during the elapsed interval, but this with the sun seldom happens. The observation must, therefore, be corrected by a table, or by a direct calculation.

Equal *Angles*, are those whose containing lines are inclined alike to each other, or which are measured by similar arcs of their circles.

Equal *Arithmetical Ratios*, are those wherein the difference of the two less terms is equal to the difference of the two greater.

Equal *Curvatures*, are such as have the same or equal radii of curvature.

Equal *Figures*, are those whose areas are equal, whether the figures be similar or not.

Equal *Geometrical Ratios*, are those whose least terms are similar aliquot or aliquant parts of the greater.

Equal *Solids*, are those whose capacities are equal.

EQUALITY, in Algebra, is a comparison of two quantities which are in effect equal, though differently expressed or represented; and it is usually denoted by two parallel lines, as =; thus $4 + 4 = 8$; that is, 4 added to 4 is equal to 8. But some writers use the character ∝, and others again χ, for expressing equality; but the two lines are now generally adopted. In the solution of a numeral problem, which is to be rendered rational, if there be only one formula, to be equal to a square or other higher power, it is called a *simple* equality.

EQUANIMITY, in Ethics, denotes that even and calm frame of mind and temper under good or bad fortune, whereby a man appears to be neither puffed up nor overjoyed with prosperity, nor dispirited, soured, nor rendered uneasy by adversity.

EQUATED BODIES, on the *Gunter Scale*, is the name of two lines, which relates to the comparison of the sphere and the regular bodies; they are, however, seldom given on modern scales.

EQUATION, in Algebra, is any expression in which two quantities differently represented are put equal to each other, by means of the sign = placed between them; thus $7ax + 3x = b$, $5y^2 + 3y - a = 0$, $7x^3 + 3x^2 - 11 = 0$, &c. are equations, and these receive different names, according to the various circumstances of the powers, relations, and combinations of the unknown quantities which enter into them.

A *Literal* EQUATION, is that in which all the quantities, both known and unknown, are expressed by letters, as $ax^2 + bx = c$.

A *Numeral* EQUATION, is that in which the co-efficients of the unknown quantity and absolute terms are given numbers, as $5x^2 + 7x = 16$, $x^3 - 1ax - 1 = 0$, &c.

A *Simple* EQUATION, is that in which the unknown quantity enters only in the first degree, as $7x = 35$, $ax + bx = c$, $3ax + 5bx = 119$, &c.; and these are always better expressed by putting all the co-efficients under a parenthesis, with the unknown quantity outside, thus $(a + b)x = c$, $(3a + 5b)x = 119$, &c.

A *Quadratic* EQUATION, is that which the unknown quantity enters into the second degree, as $ax^2 = b$, $ax^2 + bx = c$, &c.

Note. When only the second power enters, as $ax^2 = b$, it is called a *Simple Quadratic*; and when the second and first both occur in the same equation, it is called an *Adfected Quadratic*; such are the equations $ax^2 + bx = c$, $x^2 + a = bx$, &c.

A *Cubic* EQUATION, is that in which the third power of the unknown quantity enters, as $x^3 + ax^2 + bx = c$, $x^3 + ax = b$, $ax^3 = c$, &c. The latter of which is called a *Simple Cubic*.

A *Biquadratic* EQUATION, is that in which the fourth power of the unknown quantity enters, as $ax^4 + bx^3 + cx^2 + dx = e$; and when only the fourth power enters, it is called a *Simple Biquadratic*.

Reduction of EQUATIONS, is of two kinds, *viz.* first, the reduction of them from a higher to a lower dimension; and, second, the reduction of them to some particular form, to prepare them for solution. The former of these cases is more commonly called the *Depression* of *Equations*, which see; and the latter usually consists in exterminating the second term of the equation, this being the most eligible form for solution. Some authors also use the term *Reduction of Equations*, for what is more usually and properly called the *Solution* of *Equations*.

Solution of EQUATIONS, is the method of finding their roots, which, however, can only be done in a direct manner, for the first four degrees, *viz.* in *Simple*, *Quadratic*, *Cubic*, and *Biquadratic Equations*; and the several methods of procedure, in each of these, is given under the annexed examples. Equations that exceed the fourth degree cannot be solved by any direct rule, (except in a few partial cases, in which there are certain relations either between the roots or co-efficients,) although the subject has been investigated by many of the ablest analysts of Europe. We have, therefore, no means of obtaining the roots in those cases, but by approximation.

Questions which involve Equations containing only One unknown Quantity.—*Question* 1. There are two numbers whose difference is 12, and their sum 20; what are the numbers?

As their difference is 12, the *greater* number must evidently exceed the less number by 12.

Solu. Let $x =$ the *less* number; then $x + 12$ will be the *greater*. But by the equation, the *sum* of the two numbers is 20; or, the greater + the less number = 20.

Hence, by addition, $(x + 12) + x = 20$.

That is, $2x + x \quad .. \quad = 20$.

therefore, $2x \quad .. \quad = 20 - 12 = 8$.

and .. $x \quad .. \quad = \frac{8}{2} = 4$ the *less* No.

Hence the *greater* number $= x + 12 = 4 + 12 = 16$.

Question 2. There are two numbers whose difference is 9, and if three times the *greater* be added to five times the *less*, the sum will be 35; what are those two numbers?

Solu. Let $x =$ the *less*; then $\overline{x + 9} =$ the *greater* number.

And 3 *times* the *greater* $= 3 \times \overline{x + 9} = 3x + 27$.

5 *times* the *less* $= 5 \times x \quad 9 = 5x$.

But, by the condition of the question, 3 times the greater + 5 times the less number = 35.

Hence, by addition, $(3x + 27) + 5x = 35$;

That is, $8x + 27 = 35$, or $8x = 35 - 27 = 8$;

$\therefore x = \frac{8}{8} = 1 =$ the *less* number;

and $x + 9 = 1 + 9 = 10$ the *greater* number.

Question 3. What number is that, to which if we add 10, three-fifths of the sum shall be 66?

Solu. Let $x =$ the number sought, then $x + 10 =$ the number + 10.

Now, $\frac{3}{5}$ths of $x + 10 = \frac{3}{5} \times \overline{x + 10} = \frac{3 \times \overline{x + 10}}{5} = \frac{3x + 30}{5}$

But, by the question, $\frac{3}{5}$ths of $\overline{x + 10} = 66$.

Hence, by substitution, $\frac{3x + 30}{5} = 66$.

Multiplying by 5, we have $3x + 30 = 330$;

$\therefore 3x = 330 - 30 = 300$, and $x = \frac{300}{3} = 100 =$ the required No.

Question 4. What is the number which, being multiplied by 6, the product increased by 36, and that sum divided by 18, the quotient shall be 20?

Solu. Let $x =$ the number sought.

Then $6x =$ the number multiplied by 6.

Also $6x + 36 =$ the product increased by 36,

And $\frac{6x + 36}{18} =$ that sum divided by 18.

Hence, by the question, $\frac{6x + 36}{18} = 20$.

And $6x + 36 = 360$, multiplying by 18,

or $6x = 360 - 36 = 324$;

$\therefore x = \frac{324}{6} = 54$, the number required.

Question 5. A post is one-fifth in the earth, three-sevenths in water, and 13 feet out of water; what is the length of the post?

Solu. Let $x =$ the length of the post;

Then $\frac{x}{5} =$ the part of it in the earth;

Also $\frac{3x}{7} =$ the part of it in the water;

And $13 =$ the part of it out of the water;

But the part in earth + part in water, + part out of water = the whole post.

Therefore $\frac{x}{5} + \frac{3x}{7} + 13 = x$.

Multiply by 5, then $x + \frac{15x}{7} + 65 = 5x$.

by 7, and $7x + 15x + 455 = 35x$;

or $455 = 35x - 7x - 15x = 13x$

Hence $x = \frac{455}{13}, = 35$ feet, the length of the post.

Question 6. Having paid away one-fourth and one-seventh of my money, I had eighty-five pounds left in my purse; how much money was in it previously to these disbursements?

Solu. Let $x =$ the money in purse at first; then $\frac{x}{4} + \frac{x}{7}$ is the money paid away.

Now, by the question, $x = \frac{x}{4} + \frac{x}{7} + 85$; multiply by 28,

Then $28x = 7x + 4x + 2380$, or $17x = 2380$;

Therefore $x = \frac{2380}{17} = £140$. the money at first in my purse.

Problems, or *Questions*, involving quadratic equations, are solved by the same process as that for the solution of those which contain simple equations. But as every quadratic equation contains two values of the unknown quantity, questions of this class may admit of a double solution. And as the particular nature of the question must determine whether one or both of these values may apply to it, no *general* rule can be laid down, yet may the processes of solution of problems involving quadratic equations be sufficiently understood by observing the conclusions deduced from the following examples.

Example 1. To find that number to which, if you add 12, and multiply the sum by the number required, the product shall be 589.

Solu. Let $x =$ the number sought;
Then $(x + 12)x = 589$, or $x^2 + 12x = 589$ by the question.
Complete the square, or add to each side of the equation the square of half the co-efficient of the second term, and we have $x^2 + 12x + 36 = 625$; hence,
extract the root, and we get $x + 6 = \sqrt{625} = 25$;
Therefore, $x = 25 - 6 = 19$, the number sought.

Example 2. To divide the number 56 into two such parts, that their product shall be 640.

Solu. Let $x =$ *one* part; then $56 - x =$ the *other* part;
And $x \times (56 - x) =$ the *product* of the two parts.
Hence, $x \times (56 - x) = 640$, or $56x - x^2 = 640$ by the question, or $x^2 - 56x = -640$; hence
by completing the square, $x^2 - 56x \pm 784 = 784 - 640 = 144$;
Therefore, $x - 28 = + \sqrt{144} = \pm 12$;
and, consequently, $x = 28 \pm 12 = 40$ or 16.

Note. The *two* values of the unknown quantity are, in this instance, the *two* parts into which the given number was required to be divided.

Example 3. Let the difference of two numbers be 7, and half their product *plus* 30 be equal to the square of the *less* number; it is required to find those two numbers:

Solu. Let $x =$ the less, then $x + 7 =$ the greater number,
And $\frac{x(x+7)}{2} + 30 =$ half their product *plus* 30.

Hence $\frac{x(x+7)}{2} + 30 = x^2$ (square of the *less*) or $\frac{x^2 + 7x}{2} + 30 = x^2$ by the question.

Multiply now by 2, and $x^2 + 7x + 60 = 2x^2$.
Or, by transposition, $x^2 - 7x = 60$; hence
by completing the square $x^2 - 7x + \frac{49}{4} = 60 + \frac{49}{4} = \frac{289}{4}$;

Consequently, $x - \frac{7}{2} = \pm\sqrt{\frac{289}{4}} = \pm\frac{17}{2}$,

Therefore $x = \frac{\pm 17 \pm 7}{2} = 12$, or $-5 =$ *less* part:

And $x + 7 = 12 + 7$, or $-5 + 7 = 19$, or $2 =$ the *greater* part.

Note. This problem, we see, admits of a double solution; for whether 12 and 19 or − 5 and 2 be taken as the corresponding *less* and *greater* parts, the conditions of the question are answered by each pair of numbers.

Illus. Thus the difference of 12 and 19 .... is 7.
That of − 5 and 2 .... is 7.

Half product of 12 and 19 + 30 + $\frac{(12 + 19)}{2} + 30 = 144 = \overline{12}|^2 =$ *square of the less.*

That of − 5 and 2 + 30 = $\frac{(-5 \times 2)}{2} + 30 = 25 = -\overline{5}|^2 =$ *square of the less.*

Example 4. To divide the number 30 into two such parts that their product may be equal to eight times their difference.
Solu. Let $x =$ the *less*; then $30 - x =$ the *greater* part,
And $30 - x - x$, or $30 - 2x =$ their *difference*.
Hence, $x \times (30 - x) = 8(30 - 2x)$, by the question,
or, which is the same, $30x - x^2 = 240 - 16x$.
Or, by transposition, $x^2 - 46x = -240$.
Complete the square, and $x^2 - 46x + 529 = 529 - 240 = 289$,
Therefore, $x - 23 = \pm\sqrt{289} = \pm 17$,
Whence, $x = 23 \pm 17 = 40$ or $6 =$ *less* part.
And $30 - x = 30 - 40$ or $30 - 6 = -10$ or $24 =$ *greater* part.
Here the equation gives for the less part 40 and 6; but as 40 cannot possibly be a part of 30, we take 6 for the less part which allows 24 for the greater; and the two numbers 24 and 6 answer the conditions of the question.

Example 5. A merchant bought cloth for £33. 15s. which he sold again at £2. 8s. per piece, and gained by the bargain as much as one piece cost him: what did he gain by the bargain?
Solu. Let $x =$ the *number* of pieces.

Then $\frac{675}{x} =$ the number of *shillings* which each piece cost;
and $48x =$ the number of shillings which he *sold* the whole for.
Therefore $48x - 675 =$ what he gained by the bargain.

But $48x - 675 = \frac{675}{x}$, by the question,

and $x^2 - \frac{225}{16}x = \frac{225}{16}$, by transposition and division.

Then comp. the sqr. and $x^2 - \frac{225}{16}x + \frac{50625}{1024} = \frac{225}{16} + \frac{50625}{1024} = \frac{65025}{1024}$,

Therefore $x - \frac{225}{32} = \pm \sqrt{\frac{65025}{1024}} = \frac{\pm 255}{32} \sqrt{\frac{65025}{1024}}$

And $x = \frac{\pm 255 + 225}{32} = 15$ or $\frac{-30}{32}$.

But it is obvious the number required is 15, because the conditions of the question are such that there cannot be a *negative* or *fractional* number of pieces.

Example 6. A and B set off at the *same time* to a place at the distance of 150 miles from that which they left; A travels 3 miles an hour *faster* than B, and arrives at his journey's end 8 hours 20 minutes *before* him: it is required to find what rate each person travelled per hour.
Solu. Let $x =$ the *rate* per hour at which B travels.
Then $x + 3 =$ the *rate* per hour at which A travels.
And $\frac{150}{x} =$ the *number* of hours for which B travels.

Also $\frac{150}{x+3} =$ the *number* of hours for which A travels.

But A arrives 8 hours 20 minutes ($8\frac{1}{3}$ hours) sooner at his journey's end than B;

Hence $\frac{150}{x+3} + 8\frac{1}{3} = \frac{150}{x}$, or $\frac{150}{x+3} + \frac{25}{3} = \frac{225}{x}$.

But, by reduction, we get $x^2 + 3x = 54$.

And completing the square $x^2 + 3x + \frac{9}{4} = 54 + \frac{9}{4} = \frac{225}{4}$;

Therefore, $x + \frac{3}{2} = \sqrt{\frac{225}{4}} = \frac{\pm 15}{2}$;

And $x = \frac{\pm 15 - 3}{2} = 6$ or -9 miles an hour for B.

Whence $x + 3 = 9$ or -6 miles an hour for A.

Since this is a question of *motion*, it is evident that if motion *to a place* be reckoned *positive*, motion from the same place must be reckoned *negative*: But A and B are moving to a given place, therefore the *positive* numbers 6 and 9 are taken for the respective rates per hour of A and B.

Example 6. It is required to divide the number 14 into two such parts that their product shall be 50.

Solu. Let $x =$ one part; then $14 - x =$ the other part; Hence, by the question, $x \times (13 - x) = 50$, or $14x - x^2 = 50$;

Therefore, $x^2 - 14x = -80$,

And $x^2 - 14x + 49 = -50 + 49 = -1$, or $x - 7 = \pm \sqrt{-1}$;

Therefore, $x = 7 + \sqrt{-1}$.

But both the values of x are impossible, because the question itself is impracticable.

Equation of *Payments*, in Arithmetic, is the finding the time to pay at once several debts due at different times, and bearing no interest till after the time of payment, so that no loss shall be sustained by either party. The rule commonly given for this purpose is as follows:—Multiply each sum by the time at which it is due; then divide the sum of the products by the sum of the payments, and the quotient will be the time required.

Thus, for example, A owes B £190, to be paid as follows; *viz.* £50 at 6 months, £60 at 7 months, and £80 at 10 months, what is the equated time at which the whole ought to be paid, that no loss may arise either to debtor or creditor?

By the rule,
$$\begin{array}{rcrcl} 50 & \times & 6 & = & 300 \\ 60 & \times & 7 & = & 420 \\ 80 & \times & 10 & = & 800 \\ \hline 190 & & &) & 1520\,(\ 8 \text{ months equat. time.} \\ & & & & 1520 \end{array}$$

This rule, however, is founded on a supposition, that the interest of the several debts which are payable before the equated time, from their terms to that time, ought to be equal to the sum of the interests of the debts payable after the equated time, from that time to their terms respectively, which, however, is not correct, as it is only the discount, and not the interest in the latter sums. In most cases, however, that occur in business, the error is so trifling, that the popular rule will probably always be made use of, as being by far the most eligible and expeditious method that we could suggest.

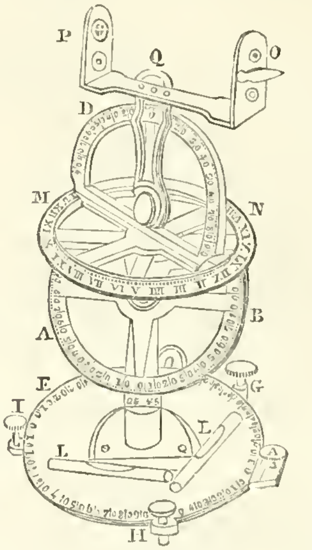
Equation, in Astronomy, is a term used to express the correction or quantity to be added to, or subtracted from, the mean position of a heavenly body, to obtain the true position; it also, in a more general sense, implies the correction arising from any erroneous supposition whatever. Thus, for instance, the time of noon, as determined by taking equal altitudes of the sun, is first obtained by supposing the sun's declination constant during the whole interval, which false supposition is corrected by an appropriate equation.

Equation of *Time*, in Astronomy, denotes the difference between mean and apparent time, or the reduction of the apparent unequal time, or motion of the sun or a planet, to equable and mean time, or motion.

If the earth had only a diurnal motion, without an annual, any given meridian would revolve from the sun to the sun again; in the same space of time as from any star to the same star again, because the sun would never change his place with respect to the stars. But as the earth advances almost a degree eastward in its orbit in the time that it turns eastward round its axis, whatever star passes over the meridian on any day with the sun, will pass over the same meridian on the next day when the sun is almost a degree short of it, that is, 3 minutes 56 seconds sooner. If the year contained only 360 days, as the ecliptic does 360 degrees, the sun's apparent place, so far as his motion is equable, would change a degree every day, and then the sidereal days would be 4 minutes shorter than the solar. The mean and apparent solar days are never equal, except when the sun's daily motion in right ascension is 59″; which is nearly the case about the 15th of April, the 15th of June, the 1st of September, and 24th of December, when the equator is 0′, or nearly so; and it is at its greatest about the 1st of November, when it is 16′ 14″.

EQUATOR, in Astronomy and Geography, is a great circle of the sphere, equally distant from the two poles of the world. It is called the equator, because when the sun is in this circle the days and nights are equal in all parts of the world. Whence also it is called *Equinoctial*; and when drawn on maps and planispheres, it is called the *Equinoctial Line*, or simply the *Line*. And since every point of the equator is equally distant from the poles of the world, it follows that the equator divides the sphere into two equal hemispheres; that towards the north pole being called the northern, and the other the southern hemisphere. As equal or mean time is estimated by the passage of arcs of the equator over the meridian, it frequently becomes necessary to convert parts of the equator into time, and the converse, which is performed by the following analogy, *viz.* As 15° : 1 hour : : any arc of the equator : the time it has been in passing. Or, conversely, 1 hour : 15° : : any given time : the arc of the equator.—From this circle are reckoned the latitude of places, both north and south, in degrees of the meridian.

EQUATORIAL, Universal, or *Portable Observatory*, is an instrument intended to answer a number of useful purposes in practical astronomy, independent of any particular observatory. It may be employed in any steady room or place, and it performs most of the useful problems in the science, as represented in the figure.



The principal parts of this instrument are, 1. The azimuth or horizontal circle, E F, which represents the horizon of the place, and moves on a long axis Q, called the vertical axis. 2. The equatorial, or hour-circle, representing M N the equator, placed at right angles to the polar axis, AB, or the axis of the earth upon which it moves. 3. The semicircle, D, of declination on which the telescope, P O, is placed, and moving on the axis of declination, or the axis of motion of the line of collimation. The pins or screws I, G, H, are used to adjust the instrument, and place it perfectly level by the spirit levels L, L, which transverse at right angles.

The peculiar uses of this equatorial are, 1. To find the meridian by one observation only. For this purpose, elevate the equatorial circle to the co-latitude of the place, and set the declination-semicircle to the sun's declination for the day and hour of the day required; then move the azimuth and hour-circles both at the same time, either in the same or contrary direction, till you bring the centre of the cross hairs in the telescope exactly to cover the centre of the sun; when that is done, the index of the hour-circle will give the apparent or solar time at the instant of observation; and thus the time is gained, though the sun be at a distance from the meridian; then turn the hour-circle till the index points precisely at twelve o'clock, and lower the telescope to the horizon, in order to observe some point there in the centre of the glass, and that point is the meridian mark found by one observation only; the best time for this operation is three hours before or three hours after twelve at noon.

2. Point the telescope on a star, though not on the meridian, in full day-light. Having elevated the equatorial circle to the co-latitude of the place, and set the declination-semicircle to the star's declination, move the index of the hour-circle till it shall point to the precise time at which the star is then distant from the meridian, found in tables of the right ascension of the stars, and the star will then appear in the glass. Besides these uses peculiar to this instrument, it is also applicable to all the purposes to which the principal astronomical instruments, *viz.* a transit, a quadrant, and an equal altitude instrument, are applied.

EQUERRY, in the British customs, an officer of state, under the master of the horse. There are five equerries, who ride abroad with his majesty; for which purpose they give their attendance monthly, one at a time, and are allowed a table.

EQUES Auratus, is used for a knight bachelor, called *auratus*, q. d. *gilt*, because anciently none but knights were allowed to beautify their armour, or other habiliments of war, with gold.

EQUESTRIAN, a term chiefly used in the phrase *equestrian statue*, which signifies a person mounted on horseback.

EQUIANGULAR, in Geometry, is applied to figures whose angles are all equal; such are the square, and all regular figures. All equilateral triangles are also equiangular. An equilateral figure, inscribed in a circle, is always equiangular; but an equiangular figure, inscribed in a circle, is not always equilateral, except when it has an odd number of sides. If the number of the sides be even, then they may be either all equal, or else half of them will always be equal to each other, and the other half to each other; the equals being placed alternately.

Equiangular, is also applied to any two figures of the same kind, when each angle of the one is equal to a corresponding angle in the other, whether each figure, separately considered, be an equiangular figure or not; that is, having all its angles equal to each other. Thus, two triangles are equiangular to each other, if one angle in each be of 30°, a second angle in each of 50°, and the third angle of each equal to 100°. Equiangular triangles, according to the above acceptation of the term, have not their like sides necessarily equal, but proportional to each other; and such triangles are always similar to each other.

EQUICRURAL Triangle, is what we more usually call an isosceles triangle. The term is derived from *æquus*, equal, and *crura*, legs, *equal legs*.

EQUICULUS, Equuleus, or Equus *Minor*, in Astronomy, a constellation in the northern hemisphere.

EQUIDIFFERENT, in Arithmetic, is when, in a series of quantities, there is the same difference between the first and second, as between the second and third, third and fourth, &c. and they are then said to be continually equidifferent; but if, in a series of quantities there be only the same difference between the first and second, as between the third and fourth, fifth and sixth, &c.; then they are said to be discreetly equidifferent. Thus 3, 6, 7, and 10, are discreetly equidifferent; and 3, 6, and 9 continually equidifferent.

EQUIDISTANT, in Geometry, a term of relation between two things which are every where at the same, or at equal distances, from each other.

Equidistant *Ordinates, Method of*, is an approximation towards the area of a figure bounded by a right line and curve. Having measured any odd number of equidistant ordinates, put the sum of the first and last $= A$, the sum of the second, fourth, sixth, &c. $= B$, the sum of all the others $= C$, and the common distance of the ordinates $= D$; then $\frac{A + 4B + 2C}{3} \times D =$ area nearly. And the same formula is applicable to the mensuration of solids, by taking the sections instead of the ordinates.

EQUILATERAL, (from *æquus* and *latus*, side,) is applied to those figures whose sides are all equal. Thus, an equilateral triangle is that whose sides are all equal. To find the area of an equilateral triangle, multiply the square of the side by $\frac{1}{4}\sqrt{3}$.

EQUILIBRIUM Equipoised, in Mechanics, means an equality of forces acting in opposite directions, whereby the body acted upon remains at rest, or in *equilibrio*, in which state the least additional force being applied, on either side, motion will ensue. A body in motion is also said to be in equilibrio, when the power producing the motion, and the force whereby it is resisted, are so adjusted that the motion may be uniform.

EQUIMULTIPLES, the products arising from the multiplication of any two or more primitive quantities, by the same number or quantity.

$$\text{Thus, } \left.\begin{array}{r} 3a,\ 3b \\ na,\ nb \\ ma,\ mb \end{array}\right\} \text{ are equimultiples of } a \text{ and } b.$$

Equimultiples of any quantities have the same ratio as the quantities themselves; thus, $a : b :: na : nb$; and $a : b :: ma : mb$.

EQUINOCTIAL, in Astronomy, a great circle of the sphere, under which the equator moves in its diurnal motion. The equinoctial is conceived, by supposing a semidiameter of the sphere produced from a point of the equator, and there, by the rotation of the sphere about its axis, describing a circle on the immoveable surface of the heavens. The poles of this circle are the poles of the world. The sphere is divided by it into two equal parts, the northern and southern. It intersects the horizon of any place in the east and west points; and at the meridian, its elevation above the horizon is equal to the co-latitude of the place. Whenever the sun, in his progress through the ecliptic, comes to this circle, it makes equal days and nights in all parts of the globe; as he then rises due east, and sets due west, which he never does at any other time of the year. And hence the denomination from *æquus* and *nox*, because *day and night are equal*. All the stars under this circle, or that have no declination, rise due east, and set due west. The equinoctial, then, is the circle which the sun describes, or appears to describe, at the time of the equinoxes, that is, when the length of the day is every where equal to that of night, which happens twice a year. From this circle is the declination in the heavens, or latitude of places on the earth, counted in degrees of the meridian. Upon this circle is reckoned the longitude 180° west, and 180° east; and in all 360°. Hence 1° of longitude answers to 4′ of time, 15′ to 1′ of time, and 1′ to 4″ of time, &c. The shadows of those who live under this circle are cast to the southward for one half of the year, and to the northward during the other half; and twice in a year, *viz.* at the equinoxes, the sun at noon casts no shadow, being in their zenith.

Equinoctial *Colure*, is that passing through the equinoctial points. *See* Colure.

Equinoctial *Dial*, is one whose plane is parallel to the equinoctial. The properties or principles of this dial are: 1. The hour lines are all equally distant from one another, quite round the circumference of a circle; and the style is a straight pin, or wire, set up in the centre of the circle, perpendicular to the plane of the dial. 2. The sun shines upon the upper part of this dial-plane from the 21st of March to the 23d of September, and upon the under part of the plane the other half of the year.

Equinoctial *Points*, are the two points wherein the equator and ecliptic intersect each other; the one, being in the first point of Aries, is called the vernal point; and the other, in the first point of Libra, the autumnal point.

Equinoctial *Gales*, storms which are observed generally to take place about the time of the sun's crossing the equator or equinoctial line, at which time there is equal day and night throughout the world.

EQUINOX, in Astronomy, the time when the sun enters one of the equinoctial points. The equinoxes happen when the sun is in the equinoctial circle; when of consequence the days are equal to the nights throughout the world, which is the case twice a year, *viz.* about the 21st of March and the 23d of September; the first of which is the vernal, and the second the autumnal equinox. It is found by observation, that the equinoctial points, and all the other points of the ecliptic, are continually moving backward, or westward; which retrograde motion of the equinoctial points, is what is called the *precession of the equinoxes. See* Precession.

It appears from the result of calculations, that the path of either of the poles is a circle, the poles of which coincide with those of the ecliptic, and that the pole will move along that circle so slowly as to accomplish the whole revolution in about 25,791 years nearly. The diameter of this circle is equal to twice the inclination of the ecliptic to the equator, or about 47 degrees. Now, as the ecliptic is a fixed circle in the heavens, but the equator, which must be equidistant from the poles, moves with the poles, therefore the equator must be constantly changing its intersection with the ecliptic. And from the best observations it appears, that the equator cuts the ecliptic every year 50 seconds ·25, more to the westward, than it did the year before; hence the sun's arrival at the equinoctial point *precedes* its arrival at the same fixed spot of the heavens every year by 20 minutes 23 seconds of time, or by an arc of 50 seconds ·25. Thus, by little and by little, these equinoctial points will cut the ecliptic more and more to the westward, till after 25,791 years. they return to the same point precisely.

EQUITY, *quasi æqualitas.* is generally understood in Law, a liberal correction, or qualification of the law, where it is too strict, too confined, or severe, and is sometimes applied where, by the words of a statute, a case does not fall within it, yet being within the mischief, the judges, by an equitable construction, have extended its application to that case. Equity is understood as a correction of the law; and hence, the court of chancery, and the court of exchequer, act as courts of equity; they are also courts of law. There are some cases which belong, peculiarly, to a court of chancery, as the care of infants, and appointing guardians to them, so of lunatics and charities, in which the chancellor acts for the king as keeper of his conscience. In other cases, as in the cases of trust, matters of fraud, account, suits for a discovery, matters of accident, and the like, courts of equity act in aid of the courts of law, and give relief where, from the nature of the case, a court of law cannot relieve. Thus, where an agreement is to be performed, courts of law can only give damages for the breach, but a court of equity, taking all the circumstances into consideration, directs and enjoins a specific performance of it according to good conscience. So, where it apprehends an injury likely to be done, it will interfere to prevent it.

EQUITY *of Redemption.* Upon a mortgage, although the estate upon nonpayment of the money becomes vested in the mortgagee, yet equity considers it only a pledge for the money, and gives the party a right to redeem, which is called his equity of redemption. If the mortgagee is desirous to bar the equity of redemption, he may oblige the mortgager either to pay the money, or be foreclosed of his equity, which is done by proceedings in chancery by bill of foreclosure.

EQUUS, *the Horse,* a genus of the mammalia class, of the order of belluæ.

EQUULEUS, EQUICULUS, and EQUUS *Minor*, the *Horse's Head*, one of the northern constellations, which represents, according to the poets, the horse which Mercury gave to Castor, and which he named *Celeris.* From the imperfect representation of the animal in this constellation, the head only being imagined, it has obtained the name of *Equi Sectio.* Pegasus, we suspect, being a symbol that perpetuates the first emigration of the Cimri. Can the *Little Horse* be a chronological symbol of the second irruption of the north-eastern nomadic nations into Egypt somewhere about 2500 years ago?—*Boundaries and Contents.* North and west by Delphinus, south by Aquarius, east and north by Pegasus; right ascension 316°, declination north 5°. Number of stars, 10.

ERATOSTHENES, a Greek of Cyrene, librarian of Alexandria, under King Euergetes, son of Ptolemy Philadelphus. He died 194 years before Christ; and was called the Cosmographer, because he was the first who discovered the method of measuring the bulk and circumference of the earth.

ERICA, *Heath*, a genus of the monogynia order, in the octandria class of plants, and in the natural method ranking under the 18th order, bicornes. There are upwards of 100 species, four of which are natives of Britain.

ERIDANUS, or THE RIVER PO, is a much fabled constellation; but we may notice chiefly the story which attributes its celestial honours to the accidental circumstance of Phaeton's tumbling into it when Jove hurled the daring charioteer from the skies. In its vicinity the sisters of that rash youth were metamorphosed into poplars, and their tears into amber, an article which, however, is found chiefly on the Baltic Prussian shores. If, however, we refer the stream of Orion to the Deluge, the constellation of that name being taken as a type of the diluvian Patriarch,—the River of Aquarius, which Piscis Australis appears to swallow, may then indicate the recession of the waters from the submerged earth, and their confinement within the bed of the ocean, a fish being the hieroglyphic of the great deep;—or the Eridanus may have allusion to the same catastrophe; for the termination of the stream in the horizon might, to the people of Egypt, indicate its being swallowed up by Typhon, the lower hemisphere,—or the ocean.

The boundaries and contents of this immense constellation, wind from Orion to Cetus, and thence in a serpentine form to the Phœnix. According to the Britannic Catalogue, there are eighty-four stars in Eridanus, *viz.* one of the 1st magnitude, one of the 2d, eight of the 3d, twenty-one of the 4th, &c. The brilliant called *Achernar*, of the first magnitude, has 1 ho. 31 mi. 4 sec. right-ascension in Time, or in degrees of the Equator, 22° 46′, and 58° 8′ 35″ declination S.; of course it is never visible in our northern latitudes. It culminates half an hour before the chief star in Aries, or by the following table in astronomical time:

MONTH.	CULM.			MONTH.	CULM.			MONTH.	CULM.		
	ho.	mi.	sec.		ho.	mi.	sec.		ho.	mi.	sec.
Jan.	6	43	41	May	22	55	6	Sept.	14	48	34
Feb.	4	31	59	June	20	52	34	Oct.	13	0	46
Mar.	2	43	2	July	18	48	38	Nov.	11	4	45
April	0	49	36	Augt.	16	44	15	Dec.	9	1	13

The course of the Eridanus is easily traced from *Rigel* in the foot of Orion, and under the Bull to Cetus, and thence S. E. and S. W., till it is lost in the horizon, or more properly in its termination at the Phœnix.

ERINACEUS, *Hedgehog*, a genus of quadrupeds of the order of feræ.

ERROR, in Law, signifies an error in pleading, or in the process; and the writ which is brought for remedy thereof, is called a writ of error.

ERROR, in Astronomy, is the difference between the places of any of the heavenly bodies, as determined by calculation and observation. Thus the error in the lunar tables is the difference between the place of the moon, as given in the tables, and as determined by observation; and this error is marked with the sign + or —, according as it is to be added to or subtracted from the tabular result.

ERUCTATIONS, in Medicine, the effect of flatulent foods, and the consequent crudities.

ERUPTION, in Medicine, a sudden and copious excretion of humours, and the same with exanthema, or breaking out; as the pustules of the plague, small-pox, measles, &c.

ERYSIPELAS, in Medicine, an erruption of a fiery or acrid humour which chiefly attacks the face.

ESCALADE, in War, a furious attack of a wall or a rampart; carried on with ladders, to pass the ditch or mount the rampart, without proceeding in form, breaking ground, or carrying on regular works to secure the men.

ESCAPE, in Law, is where a person arrested gains his liberty before he is delivered by law. Escapes are either in civil or criminal cases; and may be distinguished into voluntary and negligent; voluntary, where it is with the consent of the keeper; negligent, where it is for want of due care. In civil cases, after the prisoner has been suffered voluntarily to escape, the sheriff can never after retake him, and must answer for the debt, but the plaintiff may retake him at any time. In the case of a negligent escape, the sheriff, upon fresh pursuit, may retake the prisoner, and the sheriff shall be excused if he has him again before any action is brought against himself for the escape. In criminal cases, an escape of a person arrested is an offence against public justice, and the party is punishable by fine and imprisonment.

ESCHEAT, in Law, denotes an obstruction of the course of descent, and a consequent determination of the tenure by some unforeseen contingency; in which case, the land naturally results back to the original grantor, or lord of the fee.

ESCUTCHEON, in Heraldry, is derived from the French *escusson*, and that from the Latin *scutum*, signifying the shield whereon coats of arms are represented.

ESCUTCHEON, *of Pretence*, that on which a man carries his wife's coat of arms; being an heiress, and having issue by her. It is placed over the coat of the husband.

ESCUTCHEON, the compartment in the middle of the ship's stern, where her name is written.

ESOX, *Pike*, a genus of fishes of the order abdominales. The common pike is a native of most of the lakes and smaller rivers in Europe, but the largest are those of Lapland, which are sometimes eight feet in length. The largest in this country is said to have weighed thirty-five pounds. The head of the pike is flat; the upper jaw broad, and shorter than the lower, the teeth are very sharp, and the number, not less than seven hundred, without reckoning those nearest the throat: it is also to be observed, that those which are situated on the jaws are alternately fixed and moveable; the gape is very wide, and the eyes small. The usual colour of this fish is a pale olive-gray, deepest on the back, and marked on the sides by yellowish spots: the abdomen is white, spotted with black.

ESPALIERS, rows of trees planted about a garden, and trained up regularly to a lattice of wood-work in a close hedge, for the defence of tender plants.

ESPLANADE, in Fortification, the sloping of the parapet of the covered way towards the champaign; the same with glacis.

ESPLEES, in Law, the general products which lands yield, or the profit or commodity which is to be taken or made of a thing.

ESQUIRE, anciently the person that attended a knight in the time of war, and carried his shield. Those to whom the title of esquire is now of right due, are all noblemen's younger sons; and the eldest sons of such younger sons; the eldest sons of knights, and their eldest sons; the officers of the king's courts, and of his household; counsellors at law, justices of the peace, &c., though those latter are only esquires in reputation: besides, a justice of the peace holds this title no longer than he is in commission, in case he is not otherwise qualified to bear it; but a sheriff of a county, who is a superior officer, retains the title of esquire during life, in consequence of the trust once reposed in him; the heads of some ancient families are esquires by prescription.

ESSENCE, in Philosophy, the particular nature of each genus or kind, and that which distinguishes it from all others.

ESSENTIAL Salt of Lemons. Four ounces of cream of tartar, and eight ounces of sal acceloseliæ; well mixed together.

ESSOIN, in Law, an excuse for a person summoned to appear and answer to an action, on account of sickness or other just cause of absence.

Essoin *Day*, the first day of every term, though the fourth day after is also allowed by way of indulgence.

ESTATE, in Law, signifies such inheritance, freehold, term for years, tenantcy by statute-merchant, staple, elegit, or the like, as any man has in lands and tenements. Estates are real of lands, tenements, &c., or personal, of goods or chattels; otherwise distinguished into freeholds that descend to the heir, and chattels which go to the executors.

ESTIVAL, belonging to, or continuing for, the summer.

ESTOPPEL, in Law, an impediment or bar to an action, which arises from a person's own act; or where he is forbidden by law to speak against his deed, which he may not do, even to plead the truth.

ESTOVERS, in Law, a liberty of taking necessary wood for the use or furniture of a house or farm.

ESTRAYS and WAIFS. Estrays are any valuable beasts, not wild, found within a lordship whose owner is not known; such as are commonly impounded and not claimed. They are then to be proclaimed in the church and two nearest market-towns, on two market-days, and not being claimed by the owner, belong to the king, and now commonly, by grant of the crown, to the lord of the manor, or the liberty.—Waifs are goods which are stolen, and waved, or left by the felon on his being pursued, for fear of being apprehended; and forfeited to the king or lord of the manor.

ESTREAT, in Law, is a true copy or note of some original writing on record.

ETCHING, one species of engraving on copper, the lines being corroded in with aqua fortis, instead of being cut with a graver, which, for many purposes, is superior to engraving; but there are others in which the subjects must be graved, not etched. In general, in engravings on copper executed in the stroke manner, etching and graving are combined; the plate is begun by etching, and finished with the graver. Landscapes, architecture, and machinery, receive most assistance from etching, which is not so applicable to portraits and historical designs, though in these also it has a place.

The various instruments and materials used in the art, are—

Copper-plates, prepared by the coppersmiths.

Etching-points, or *needles*, of steel, an inch long, fixed in handles of wood about six inches in length, and of the size of a goose-quill. These should be well tempered, and accurately fixed in the centre of the handle. They are brought to an accurately conical point, by rubbing upon an *oil-stone*.

A *parallel ruler*, for drawing parallel lines, is faced with brass, not to be bruised by accident.

Compasses, for describing circles and measuring distances.

Aqua fortis, or what is better, spirits of nitre (nitrous acid), to corrode the copper; a process called *biting* in. This liquid is kept in a bottle with a glass stopper, as its fumes destroy corks. A stopper of wax, or a cork well covered with wax, will serve as a substitute.

Bordering-wax, for surrounding the margin of the copper-plate, when the aqua fortis is pouring on, may be bought ready prepared, or made thus: Take one-third of bees-wax to two-thirds of pitch; melt them in an iron ladle, and pour them, when melted, into water lukewarm; then mould it with your hand till it is thoroughly incorporated, and all the water squeezed out. Form it into rolls of convenient size.

Turpentine-varnish, for covering the copper-plate, in any part where you do not wish the aqua fortis to bite, is diluted to a proper consistence with turpentine, and mixed with lamp-black, to be seen better when laid upon the plate.

Etching-ground, for covering all over the plate, previous to drawing with the needles, is prepared thus: Take of virgin-wax and asphaltum, each twenty ounces; of black-pitch and Burgundy-pitch, each half an ounce; melt the wax and pitch in a new earthenware glazed pipkin, and add to them, by degrees, the asphaltum finely powdered. Let the whole boil till such time as a drop of it upon a plate will break when it is cold, or bending it double two or three times between the fingers. The varnish being then boiled enough, is taken from the fire, and cooled a little, and poured into warm water, that it may work the more easily with the hands, into balls for use. The fire must not be too violent, lest the ingredients burn; a slight simmering will be sufficient; that while the asphaltum is putting in, and after it is mixed with them, the ingredients should be stirred with a spatula; the water into which this composition is thrown, should be nearly of the same degree of warmth with the composition, to prevent a kind of cracking, which happens when the water is cold. The varnish ought to be harder in summer than winter; it will become so if it be suffered to boil longer, or a greater proportion of the asphaltum be used. The experiment above mentioned, of the drop suffered to cool, will determine the degree of hardness or softness suitable to the season when used.

To lay the ground for etching, we clean the copper-plate with fine whiting and a linen rag, to free it from grease; and, as a handle for managing it by when warm, we fix a hand-vice to some part of it where no work is intended to be laid. We then hold the plate over burning paper or a chafing-dish, to heat it, so as to melt the etching-ground, which should be wrapped up in a bit of taffeta, to prevent any dirt, that may happen to be among it, from mixing with what is melted upon the plate. It must be heated just sufficient to melt, not to burn the ground. When a sufficient quantity of the etching-ground has been rubbed on the plate, dab it, or beat it gently, while the plate is hot, with a small dabber made of cotton wrapped in taffety. By this operation, the ground is distributed more equally over the plate, than by any other means. When the plate is thus uniformly and thinly covered with the varnish, it is blackened by smoking it with a wax-taper, thus: Twist together three or four pieces of wax-taper to make a large flame, and while the plate is still warm, hold it with the varnished side downwards, and move the smoky part of the lighted taper over its surface, till it is almost black; but let not the wick touch the varnish, lest it get smeared or stained. In laying the etching-ground, take care that no particles of dust settle upon it, as that would be found troublesome in etching; the room therefore in which it is laid should be still, and free from dust.

The ground being laid, and suffered to cool, the next operation is to transfer the design to the plate. For this purpose a tracing on oiled paper is made from the design to be etched, with pen and ink, having a very small quantity of ox's gall mixed with it, to make the oiled paper take it; also a piece of thin paper, of the same size, is rubbed over with red chalk, powdered, by means of some cotton. Then laying the red chalked paper, with its chalked side next the ground, on the plate, put the tracing over it, and fasten them both together, and to the plate, by a little bit of the bordering wax. When all this is prepared, with a blunt etching needle go gently all over the lines in the tracing, and the chalked paper will be pressed against the ground, and the lines of the tracing transferred to it.

The plate is now prepared for drawing through the lines marked upon the ground. The etching-points or needles are now employed, leaning hard or lightly, according to the degree of strength required in the lines. Points of different sizes and forms are also used, to make lines of different thickness, though this is commonly effected by the biting-in with aqua fortis. A margin or border of wax formed all round the plate, holds the aqua fortis when it is poured on. The bordering wax already described, is put into lukewarm water to soften it, and render it easily worked by the hand. When sufficiently pliable, it is drawn into rolls, and put round the edges of the plate, in a neat wall or margin. A spout is formed in one corner, by which afterwards to pour off the aqua fortis.

The nitrous acid (spirits of nitre) is now diluted with four or five times as much water, or more (according as you wish the plate to be bit quick or slow,) and poured upon the plate. In a few minutes minute bubbles of air will fill all the lines drawn on the copper. These are removed by a feather; and the plate is every now and then *swept*, as it is called, or kept free from air bubbles. By the more or less rapid production of these bubbles, you judge of the rapidity with which the acid acts upon the copper. The biting-in of the plate is the most uncertain part of the process, nothing but experience can enable any one to tell when it is bit enough, as the thickness and depth of the line cannot easily be seen till the ground is removed.

When you judge, from the time the acid has been on, and the rapidity of the biting, that those lines you wish to be the faintest are deep enough, you pour off the aqua fortis by the spout, wash the plate with water, and dry it, so as not to melt the ground. Those lines not intended to be bit any deeper are now stopped up with turpentine varnish mixed with lamp-black, and laid on with a camel's hair pencil; when this is thoroughly dry, the aqua fortis is poured on again, to bite the other lines that are to be deeper.

This process of stopping out and bitting in is to be repeated as often as lines of different degrees of thickness are to be made. It is necessary also to be careful to stop out, with the varnish, those parts from which the ground may have come off by the action of the acid, else parts will be bit that were not intended. This is called *foul-biting*.

When the biting-in is finished, remove the bordering-wax and the ground, that you may see what success you have had. To take off the bordering-wax, the plate is heated by a piece of lighted paper, which softens the wax in contact with the plate, and it comes off clean. Oil of turpentine is now poured upon the ground, and the plate rubbed with a linen rag, to remove all the ground. Lastly, it is cleaned with whiting.

The success of the etching is now known, but it is necessary to get an impression upon paper by a copper-plate printer. This impression is called a *proof*. If any parts are not bit so deep as were intended, the process is repeated, provided the lines are not too faintly bit. This re-biting is done as follows: melt some of the etching-ground on a spare piece of copper, dab it a little, to get some on the dabber; clean out with whiting the lines that are to be re-bit, heat the plate gently, dab it lightly with the dabber, and the parts between the lines will be covered with the ground, but the lines themselves will not be filled up, and consequently will be exposed to the action of the aqua fortis. This delicate process must be performed with great care. The rest of the plate is now varnished over, the bordering-wax put on again, and the biting repeated as at first. Should any part be bit too deep, it is recovered or made fainter, by burnishing the part down, or rubbing it with a piece of charcoal, which will make the lines shallower, and cause them not to print so black. Should any small parts of the lines have missed in the biting, they are cut with the graver, which is also sometimes employed to cross the lines of the etching and give it a more finished effect.

Dry-pointing, another method for softening the harsh effects usually apparent in an etching, is done by cutting with the etching-point upon the copper without any ground or varnish. This process does not make a deep line, and is used for covering the light, where delicate tints and soft shadows are wanted. By varying these processes of etching, graving, and dry-pointing, as may be necessary, the plate is worked up to the full effect intended, and then sent to the *writing engraver*, to grave whatever letters or inscriptions may be required.

ETHER, an element, supposed by some philosophers to occupy the upper regions of space, more fine and subtle than air.

ETHICS, or Morality, the science of morals or duty, which it traces from man's nature and condition, and proves to terminate in his happiness; or, in other words, it is the knowledge of our duty and felicity, or the art of being virtuous and happy.

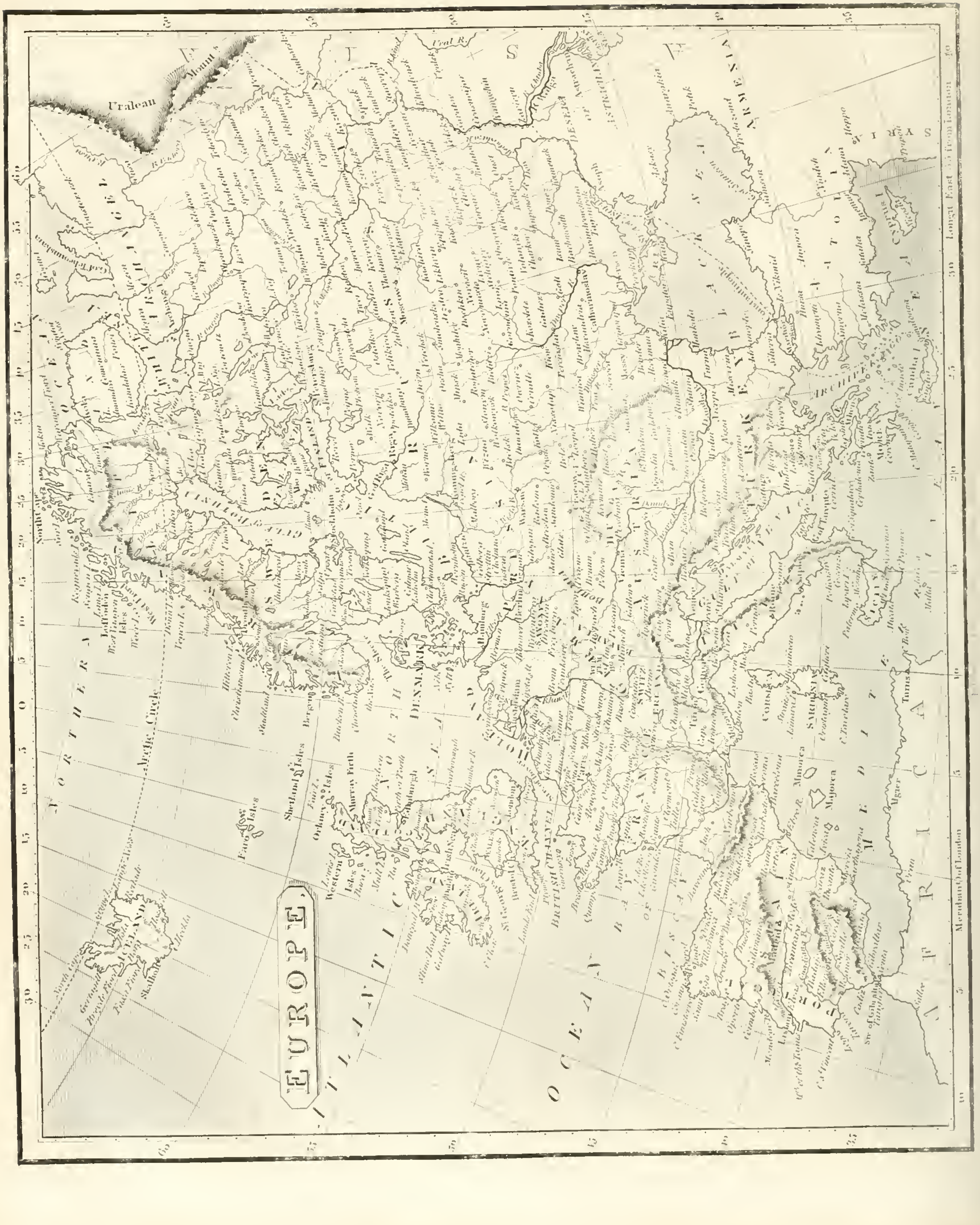
EUCLID, a celebrated mathematician of Alexandria, who flourished before Christ 300 years. He immortalized his name by his books on geometry, in which he digested all the propositions of eminent geometricians who had preceded him, as Thales, Pythagoras, and others. King Ptolemy became one of his pupils. and his school became so famous, that Alexandria continued for many ages the great university for mathematical studies.

EULER, Leonard, one of the most celebrated analysts of the last century, was born at Basil in the year 1707, and very early discovered great talents as well in the study of the Greek and Latin languages as in the various branches of the mathematical and philosophical sciences. The natural genius of Euler was also much assisted by an astonishing retentive memory, which enabled him, it is said, to repeat the whole of the Æneid of Virgil from beginning to end; and to point out to his hearers the first and last line of every page in the edition that he had accustomed himself to read. It is also farther stated, that he could remember the first six powers of all numbers under 100. Besides being foreign member of the Academy of Sciences of Paris, Euler was member of the Imperial Academy of Petersburgh, ancient director of the Academy of Berlin, and fellow of the Royal Society of London. He died at Petersburgh, where he had spent a great part of his life, on the 7th of September, 1783, in the 76th year of his age.

EUDIOMETRY, the science of determining the purity of atmospheric air, by measuring the proportion of oxygen (on which its respirable property depends) in a given quantity of it; whence the tests or instruments employed in this science are denominated eudiometers.

EUDOXUS, of Cnidus, a city of Caria in Asia Minor, a celebrated astronomer and geometer, who flourished about 370 years before Christ. He composed "Elements of Geometry," to which work, according to the account of Proclus, Euclid was much indebted for many of his propositions; indeed, some writers have attributed to him the whole of Euclid's "Elements." Eudoxus is said to have died in the year before Christ 352, in the 53d year of his age.

EUDIOMETER. An instrument for ascertaining the purity of air, or rather the quantity of oxygen contained in any given bulk of elastic fluid. Dr. Priestley's discovery of the great readiness with which nitrous gas combines with oxygen, and is precipitated in the form of nitric acid, was the basis upon which he constructed the first instrument of this kind. His method was extremely simple: a glass vessel, containing an ounce by measure, was filled with the air to be examined, which was transferred from it to a jar of an inch and a half diameter, inverted in water; an equal measure of fresh nitrous gas was added to it; and the mixture was allowed to stand two minutes. If the absorption were very considerable, more nitrous gas was added, till all the oxygen appeared to be absorbed. The residual gas was then transferred into a glass tube, two feet long, and one-third of an inch wide, graduated to tenths and hundredths of an ounce measure; and thus the quantity of oxygen absorbed was measured by the diminution that had taken place. The burning of hydrogen gas, and of phosphorus, has also been employed. The same object has also been effected by observing the quantity of oxygen absorbed by a solution of sulphuret of potash.


EUROPE
NORTHERN OCEAN
ATLANTIC OCEAN
Arctic Circle
NORTH SEA
BRITISH CHANNEL
BAY OF BISCAY
MEDITERRANEAN SEA
BLACK SEA
ARCHIPELAGO
AFRICA
ASIA
SYRIA
ARMENIA
NATOLIA
TURKEY
HUNGARY
AUSTRIA
BOHEMIA
SAXONY
PRUSSIA
POLAND
RUSSIA
FINLAND
SWEDEN
NORWAY
DENMARK
HOLLAND
FRANCE
SWITZ
ITALY
SPAIN
PORTUGAL
CORSICA
SARDINIA
SICILY
CANDIA
CYPRUS
ICELAND
Faro Isles
Shetland Isles
Orkney Isles
Western Isles
Gulf of Bothnia
Uralean Mount^s
Ural R.
Volga R.
Mayorca
Minorca
Tunis
Alger
Meridian of London
Longit East from London

EUROPE extends from the tenth degree west, to the sixtieth degree east longitude, and from the thirty-sixth to the seventy-second degree of north latitude. The Frozen Ocean bounds it on the north, Asia on the east, the Mediterranean sea on the south, and the Atlantic Ocean on the west. Its length, from east to west, is about 3300 miles; its breadth, from north to souht, about 2350.

The European states are fourteen in number; and of these, four are in the north, six in the middle, and four in the south.

The Northern States are:

Countries.	*Chief Towns.*
1. The British Isles	London, Dublin, Edinburgh.
2. Danish dominions	Copenhagen, on the Sound.
3. Sweden	Stockholm, on Lake Maelar.
4. Russia	Petersburgh on the river Neva.

The Six Middle Countries are,

1. France	Paris, on the river Seine.
2. Batavia or Holland, with the Netherlands	Amsterdam, on the river Amstel.
3. Switzerland	Basil, on the river Rhine.
4. Germany	Vienna and Presburg, on the river Danube.
5. Austrian dominions	
6. Prussia	Berlin, on the river Sprey.

The Four in the South are,

1. Spain	Madrid, on river Manzanares.
2. Portugal	Lisbon, on the river Tagus.
3. Italy	Rome, on the river Tiber.
4. Turkey	Constantinople, on the Strait of Constantinople.

A SYNOPSIS *of the European States.*

STATES.	Length.	Breadth.	Square Miles.	Inhabitants in each sq. Mile.	Religion	Government.
England	380	300	79,712	169	Prot.	Mix. M.
Scotland	303	150	27,794	62	do.	do.
Ireland	285	160	27,457	127	do.	do.
Norway	1000	300	71,400	10	do.	Monarc.
Denmark	240	280	13,744	139	do.	do.
Sweden	800	500	208,912	14	do.	do.
Prussia	600	300	56,416	99	do.	do.
Netherlands	350	300	17,520	130	do.	do.
Germany	600	526	191,573	130	P. & C.	M. & Ar.
Switzerland	150	100	14,960	28	do.	Repub.
Russia	1500	1100	1,200,000	55	Gr. C.	Despot.
Poland	540	500	160,800	75	Cath.	Monar.
Bohemia	300	250	27,734	252	do.	do.
France	600	500	160,374	174	do.	do.
Spain	700	500	150,763	74	do.	do.
Portugal	306	100	27,280	67	do.	do.
Italy	750	400	116,967	170	do.	do.
Hungary	306	200	87,575	17	do.	do.
Turkey	1400	730	181,400	44	Maho.	do.

The oceans and seas contiguous to Europe are:—1. The Atlantic ocean on the west. 2. The Frozen ocean on the north. 3. The Mediterranean sea on the south. 4. The White sea on the north of Russia. 5. The Baltic, between Denmark, Sweden, Russia, Prussia, and Germany. 6. The North sea, or German ocean. 7. The Irish sea, or St. George's channel. 8. The English channel. 9. The Adriatic, or Gulf of Venice. 10. The Archipelago, or sea of the Grecian Islands. 11. The sea of Marmora. 12. The Black sea, and the sea of Azof.

The chief European bays, gulfs, and straits, are:—1, The gulf of Bothnia, in Sweden. 2. The gulf of Finland, between Sweden and Russia. 3. The bay of Biscay, between France and Spain. 4. The gulf of Venice, between Italy and Turkey. 5. The gulfs of Riga and Dantzic, in the Baltic. 6. The gulfs of Lyons, Genoa, Taranto, and Salonica, in the Mediterranean. 7. The straits are, the Sound, between Denmark and Sweden; the strait of Dover, between England and France; of Gibraltar, between Spain and Africa; of Messina, between Italy and Sicily; of Gallipoli, into the sea of Marmora; of Constantinople, into the Black sea; and of Kaffa, into the sea of Azof.

The principal European lakes and mountains are:—Lakes Onega, Ladoga, and Peypus, in Russia; Wener and Weter, in Sweden; Neufchatel and Geneva, in Switzerland, and on the borders of France; and Lucerne, Zurich, and Constance, in Switzerland.

And the mountains are:—the Alps in Switzerland, extending in the form of a crescent, for above 500 miles. The highest part of the Alps is Mont Blanc, 15,662 feet above the level of the sea. The Pyrenees, between France and Spain, whose greatest elevation is 11,000 feet. The Apennines in Italy; the Carpathian mountains, exceeding 500 miles north and east, in Hungary; the Langfiall, or Long Mountains, and Dofrefial mountains, which separate Norway and Sweden.

The volcanoes in Europe are:—Mount Etna in Sicily, whose base is 180 miles in circumference, and its height 11,000 feet above the level of the sea. Mount Vesuvius, in the east of Naples, about 3000 feet high; and Mount Hecla, in Iceland, about 5000 feet above the level of the sea.

The European islands in the Baltic are:—Rugen, Ocland, Gothland, and Aland, belonging to Sweden; Zealand, Funen, Alsen, Langland, Laland, Falster, Femereu, and Bornholm, belonging to Denmark; and Dago and Oesel, belonging to Russia.

In the Frozen Ocean, are Nova Zembla, belonging to Russia, and Iceland, the property of Denmark.

In the Atlantic Ocean, are Great Britain and Ireland; the Orkney and Shetland islands to the north of Scotland, and the Hebrides to the west. To the north of the Shetland islands are the Ferro islands, which belong to Denmark.

In the Atlantic Ocean are also the Azore islands, the chief of which are, St. Michael, Tercera, Pico, Fayal, Florez, and Corvo. These islands belong to Portugal.

In the Irish Sea, are the isles of Man and Anglesea.

In the British Channel, are the Isles of Wight, Gersey, Guerosey, Sark, and Alderney.

In the Mediterranean, are the islands of Minorca, Majorca, and Ivica, off the coast of Spain, to which they belong. Corsica, under the government of France. Sardinia, a separate kingdom. Sicily belongs to Naples, and Malta to Great Britain. The islands of the Archipelago belong to Turkey.

The Isthmuses are those of Corinth, between the Morea and Turkey, and of Precops, in the Crimea.

The principal capes are:—1. The North cape, in Lapland. 2. The Naze, in Norway. 3. Land's End, in England. 4. Cape Clear, in Ireland. 5. Cape la Hogue, in France. 6. Cape Ortegal and cape Finisterre, in Spain. 7. Cape St. Vincent, in Portugal. 8. Cape Spartivento, in Italy; and 9. Cape Matapan, in Turkey.

The chief European rivers are:—1. The Dwina, which falls into the White sea at Archangel. 2. The Duna, which discharges itself into the Baltic at Riga. 3. The Niemen, or Memel River, separating Russia and Prussia, and which falls into the Baltic near Memel. 4. The Vistula joins the sea near Dantzic. 5. The Oder falls into the Baltic below Stettin. 6. The Elbe enters the sea near Cuxhaven. 7. The Weser runs into the sea at Bremen. 8. The Rhine falls into the German ocean at Leyden. 9. The Scheldt falls into the German ocean at Flushing. 10. The Maese joins the German ocean below Rotterdam. 11. The Seine falls into the English channel at Havre-de-Grace. 12. The Loire enters the ocean at Painbœuf. 13. The Garonne, or Gironde, falls into the sea below Bourdeaux. 14. The Minao forms the northern boundary of Portugal. 15. The Douro falls into the sea at Oporto. 16. The Tagus below Lisbon. 17. The Guadiana separates Spain from Portugal, and falls into the Atlantic. 18. The Guadalqoiver empties itself into the Atlantic at St. Lucar. 19. The Ebro falls into the Mediterranean. 20. The Rhone disembogues itself into the Mediterranean, 21. The Arno falls into the gulf of Genoa. 22. The Tiber runs into the Mediterranean. 23. The Po and the Adige fall into the gulf of Venice. 24. The Danube, the Niester, and the Dnieper fall into the Black sea. 25. The Don into the sea of Azof; and, 26. The Wolga into the Caspian sea.

The British Islands.—Great Britain is situated between 50 and 58½ degrees of north latitude, and between the 2d degree east and the 6th degree west longitude. Its length from north to south is about 580 miles, and its greatest breadth about 370. It is divided into England, Wales, and Scotland. Ireland is an integral part of the British empire.

The foreign possessions of Great Britain in Europe are:—Gibraltar, Malta, Guernsey, Jersey, and Heligoland. In North America—Canada, Labrador, New Brunswick, and their islands. In the West Indies, it possesses all the principal islands, except Cuba, Hispaniola, Porto Rico. But in lieu of these it has Honduras. In South America—Surinam, Berbice, Demerara, Essequibo, and the Falkland islands. In Africa, it possesses the Cape of Good Hope, Sierra Leone, Senegal, Goree, the isle of St. Helena, and the Isle of France. In Asia—Hindostan, the island of Ceylon, the Banda isles, &c. New Holland and its dependencies.

The population of the whole British empire is about sixty-four millions of souls; of these above forty-two millions are free people.

Thus, allowing to Great Britain........	14,956,300 souls.
To Ireland..........................	6,500,000
European dependencies...............	180,300
American dependencies...............	486,200
West Indian dependencies............	1,167,000
African dependencies................	129,000
Asiatic dependencies................	2,009,000
East India Company's dependencies....	40,600,000
Army and navy, including mercenary troops.........................	671,000
We shall have a grand total of..	66,698,800

In the year 1812, the British navy amounted to 1000 ships of war. Of these 262 were ships of the line, called also first-rates. In 1820, the peace establishment was fixed at 715 ships of war, and of these 262 were in commission, or actual service.

The revenue of 1823 was above £51,000,000, the national debt about £800,000,000. The poor-rates in England and Wales are about £8,000,000 annually. In Scotland, the poor are not provided for by *rates* or *taxes;* hence the high moral feeling and sense of independence, with the consequent industry and frugality of the Scots.

The cultivated parts of England and Wales are reckoned at thirty-nine millions of acres, the uncultivated seven millions; but of these, six millions are capable of improvement.

In Great Britain, all the manufactures common to Europe and Asia are brought to the greatest perfection.

The tonnage of British vessels cleared outwards in the year 1824, amounted to the amazing weight of 2,492,902 tons.

The British tonnage entered inwards for the year 1824, amounted to 2.960,188 tons,—

Leaving in favour of our home consumption 468,786 tons, out of which of course a considerable deduction must be made for the refuse of raw materials imported.

The transit trade is valued at £10,188,196, which is certainly a large sum to even a great commercial nation, as general carriers in a period of profound peace, when the marine of Europe, and America to boot, strike in for a large share in the competition of a transit trade.

The inland trade may be somewhere about seventy millions sterling in 1825.

The value of the exports and imports in 1824, rose to £96,488.162 sterling.

According to official statements made for the year 1821, the families employed in agriculture in Great Britain, amounted to 978,656; in trade, manufactures, or handicraft, 1,350,239; not comprised in either, 612,488; being a total of 2,941,383 families;—of which 2,346,717 were in England, 146,706 in Wales, and 447,960 in Scotland. The number of inhabited houses in Great Britain, was 2,429,630.

The Editor regrets exceedingly, that after much fruitless research in quest of authenticated returns of the annual value of each branch of our various manufactures, and the number of persons, male, female, and children, employed in each, he has been unable to complete a tabular view of our domestic industry in the arts and manufactures.

England and Wales.—England is all that portion of Great Britain south of the Tweed and the Esk, the Cheviot Hills, and the Solway Frith. On the east it is washed by the German ocean; on the south by the English channel; on the west by the Irish sea; and its northern boundary is Scotland.

Observe. The extent of England and Wales is computed at 49.453 square miles; the population is reckoned just now (1825) somewhere about 12,500,000 souls; therefore, the number of inhabitants to a square mile is nearly 254.

There are forty counties in England, and twelve in the principality of Wales.

The six Northern are:

County.	*Chief Town.*	*Situate on the River.*
Northumberland,	Newcastle,	Tyne.
Cumberland,	Carlisle,	Eden.
Durham,	Durham,	Wear.
Yorkshire,	York,	Ouse.
Westmoreland,	Appleby	Eden.
Lancashire,	Lancaster,	Lune.
The four bordering on Wales are:		
Cheshire,	Chester,	Dee.
Shropshire or Salop,	Shrewsbury,	Severn.
Herefordshire,	Hereford,	Wye.
Monmouthshire,	Monmouth.	Wye.
Twelve Midland:		
Nottinghamshire,	Nottingham,	Trent.
Derbyshire,	Derby,	Derwent.
Staffordshire,	Stafford,	Low.
Leicestershire,	Leicester,	Soar.
Rutlandshire,	Okeham,	
Northamptonshire,	Northampton,	Non.
Warwickshire,	Warwick,	Avon.
Worcestershire,	Worcester,	Severn.
Gloucestershire,	Gloucester,	Severn.
Oxfordshire,	Oxford,	Thames
Buckinghamshire,	Aylesbury,	Tame.
Bedfordshire,	Bedford,	South Ouse.
Eight Eastern.		
Lincolnshire,	Lincoln,	Witham.
Huntingdonshire,	Huntingdon,	South Ouse.
Cambridgeshire,	Cambridge,	Cam.
Norfolk,	Norwich,	Yare.
Suffolk,	Ipswich,	Orwell.
Essex,	Chelmsford,	Chelmer.
Hertfordshire,	Hertford,	Lea.
Middlesex,	London.	Thames.
Three South-Eastern:		
Surrey,	Guildford,	Wey.
Kent,	Canterbury,	Stour.
Sussex,	Chichester, or Lewes.	
Four Southern:		
Berkshire,	Reading,	Thames.
Wiltshire,	Salisbury,	Avon.
Hampshire,	Winchester,	Itchyn
Dorsetshire,	Dorchester,	Frome.
Three South-Western.		
Somersetshire,	Wells or Taunton.	
Devonshire,	Exeter,	Exe.
Cornwall,	Launceston,	Tamar.
Six in North Wales.		
Flintshire,	Flint,	Dee.
Denbighshire,	Denbigh,	Clwyd.
Caernarvonshire,	Caernarvon.	
Anglesey,	Beaumaris, on the Strait Menai.	
Merinnethshire,	Harlech or Bala.	
Montgomeryshire,	Montgomery.	
Six in South Wales.		
Radnorshire,	Radnor,	
Cardiganshire,	Cardigan,	Tivy.
Pembrokeshire,	Pembroke,	Milfordhaven.
Caermarthenshire,	Caermarthen,	Towy.
Brecknockshire,	Brecon,	Usk.
Glamorganshire,	Caerdiff,	Taafe.

The foregoing counties are again divided into six circuits, as follow:—

The Home Circuit contains Essex, Hertford, Kent, Surrey, and Sussex.

The Norfolk Circuit contains Bucks, Bedford, Huntingdon, Cambridge, Suffolk, and Norfolk.

The Oxford Circuit contains Oxford, Berks, Gloucester, Worcester, Monmouth, Hereford, Salop, and Stafford.

The Midland Circuit: Warwick, Leicester, Derby, Nottingham, Lincoln, Rutland, and Northampton.

The Western Circuit: Hants, Wilts, Dorset, Somerset, Devon, and Cornwall.

The Northern Circuit: York, Durham, Northumberland, Lancaster, Westmoreland, and Cumberland.

Chester is a county palatine, and has a separate judge.

In Middlesex the supreme courts of judicature are held.

The Universities are those of Oxford and Cambridge, and the public schools or colleges are those of Westminster, Eton, Winchester, the Charter-house, Christ's Hospital, St. Paul's, &c. The Royal Military schools, at Woolwich and Sandhurst.

Greenwich Hospital on the Thames, is the abode of aged and disabled seamen; and Chelsea Hospital contains the worn-out and maimed soldiers of Britain. At Portsmouth, Plymouth, Chatham, Deptford, Sheerness, and Milford, the dock-yards for the navy are established. And London, Liverpool, Bristol, Hull, Yarmouth, Falmouth, Sunderland, and Whitehaven, are the chief ports for the merchant shipping. Woolwich is the great arsenal for the navy, and for the *materiel* of the army.

The Isle of Wight, on the coast of England, is remarkable for its picturesque beauty;—Jersey, Guernsey, Alderney, and Sark, are on the coast of France. In the Irish sea is the Isle of Man, a poor island, but noted as the refuge of the unfortunate. The Scilly Isles are barren rocks, beyond Cornwall. The Isles of Sheppey and Thanet are on the Kentish coast; and Holy Isle, Lindisfarne, and Coquet isles, are on the Northumberland coast.

The principal mountains and hills are those of Cheviot, separating England from Scotland; the Fells, in Cumberland and Yorkshire; the Malvern Hills, in Worcestershire; the Mendip, in Somersetshire; the Peak, in Derbyshire; the Wreken, in Shropshire; and the Endle, in Lancashire; and the most elevated hills are,

	Feet High.		*Feet High.*
Whernside..........	4050	Ingleborough..........	3987
Pennygant..........	3630	Helvellyn	3324
Snowdon............	3456	Skiddaw	3270
Pendlehill...........	3411	Saddlebak............	3043
Cross Fell...........	3390		

In a geological view, England may be thus presented to the pupil. At the Land's End, massive and primitive rocks begin; upon these rest several species of transition rocks, chiefly slates of different kinds; these are succeeded by secondary strata, inclining to the horizontal position; and lastly, the alluvial matter upon which Middlesex extends. This is principally clay, and may once have formed the mud at the bottom of a salt-water lake. Proceeding northward from London, towards Scotland, we arrive, in Cumberland, at primitive rocks. These are among the highest and oldest rocks in England; and from the Land's End, the chain, passing through Cumberland, extends to the northern extremity of Scotland. In fact, the length of Britain, its general form, plains, rivers, and topographical divisions, depend on this chain of mountains, much in the same way that the continent of South America derives its general characteristics from the Cordilleras.

The chief rivers in England are: the Tweed, which separates Northumberland from Scotland. The Tyne, which forms the harbour of Newcastle. The Wear, on which Sunderland is built. The Tees, forming the boundary between Durham and Yorkshire. The Esk, on which Whitby is situated. The Humber, on which Hull stands. The Swale, in Yorkshire, navigable from Ripon. The Derwent, in Yorkshire, navigable to Malton. The Wharfe, in Yorkshire, navigable to Tadcaster. The Aire, which joins the Ouse at Howden, in Yorkshire. The Don, which joins the Ouse in an artificial canal, called the Dutch river. The Trent, which joins the Ouse at Adlingfleet, where both are lost in the Humber. The Witham, forming the port of Boston, in Lincolnshire. The Welland, forming the north-west boundary of Northamptonshire. The Nen joining the Wash below Wisbeach. The Southern Ouse, falling into the Wash at Lynn Regis. The Yare, in Norfolk, which falls into the German ocean at Yarmouth. The Deben, in Suffolk, navigable to Woodbridge. The Stour, forming the boundary between Suffolk and Essex: Harwich is at the mouth of the Stour. The Coln, flowing by Colchester. The Blackwater, in the north-west corner of Essex, near Maldon, which is joined by the Chelmer, and then forms an extensive estuary, or haven, called Blackwater Bay, famous for its oysters. The Thames, which, after receiving about eight tributary streams, falls into the sea below Gravesend, in Kent. London is situate on the left bank; Southwark on its right bank. The Medway, which, rising in Sussex, and navigable from Tunbridge, falls into the sea at Sheerness. The Stour, falling into the sea at Ramsgate. The Rother, which runs by Rye; the Ouse, by Lewes; and the Arun, by Arundel. The Itchyn, falling into Southampton Bay, and the Avon, joining the Stour, from Stourminster, and falling into the sea at Christchurch. The Exe, which joins the sea below Topsham; and the Tamar, which separates Cornwall from Devonshire. The *Towridge*, by Biddeford, and the Taw, by Barnstable, emptying themselves into Barnstaple Bay. The Avon, navigable from Bath, which falls into the Bristol channel. The Severn, which, after a course of 150 miles, forms that large arm of the sea, called the Bristol channel. The Avon, from Warwick and Stratford, joins the Severn at Tewkesbury. And the Wye falls into the Bristol channel at Chepstow. At Chepstow, the tide rises to an extraordinary height, swelling from fifty to sixty feet perpendicularly. The Towey, which runs by Caermarthen, the Tivy, by Cardigan. Milford Haven, between these, is a remarkably deep inlet of the Irish sea, and the best harbour in Britain. The Dee, which falls into the Irish sea; as does also the Mersey, the Irwell, the Ribble, and the Lune. And the Eden, which empties itself into the Solway Frith.

The principal canals in England are: one in Lincolnshire, extending from Lincoln to the Trent; another from Horncastle to Sleaford; a third from Grantham to the Trent. Liverpool is connected with Hull by a canal called the Grand Trunk, from the Trent, proceeding north to the Mersey. From the Grand Trunk, several minor canals extend in various directions; the chief of these is that branch which connects the Severn, Bristol, Liverpool, and Hull. Another canal unites the Severn with the Mersey; and from Coventry, the centre of the kingdom, canals extend to the Grand Trunk and the Grand Junction. The Union Canal is 44 miles long, from Leicester to Northampton. Gloucester and Hereford are connected by another canal. By a course of 40 miles, the Severn is united with the Thames, by a canal from Strand to Lechlade. The Oxford canal, after a course of 92 miles, joins the Coventry canal. The Grand Junction reaches from Brentford, on the Thames, and joins the Oxford canal at Braunston in Northamptonshire, after a course of 90 miles. On the south of the Thames, another canal connects Reading and Bath. The Lancaster canal stretches 74 miles from Kendal, in Westmoreland, to West Houghton, in Lancashire. The canal from Leeds to Liverpool winds through a circuit of 117 miles. The Rochdale canal is 31½ miles long The Peak Forest canal is 15 miles long; and the Chesterfield canal to the Trent is 55 miles long.

The chief watering places are, Bath, Cheltenham, Tunbridge, Harrowgate, &c. famous for their salubrious and sulphureous springs. On the sea-coast, in summer, Brighton, Ramsgate, Scarborough, Margate, Weymouth, Dawlish, and Swansea, are places of fashionable resort.

The surface and climate of England are alike varied and unequal. Thus, Wales is celebrated for lofty mountains, broken by beautiful and extensive valleys; the south of England is generally a level alluvial soil; but towards the Wash, in Lincolnshire, it is low and fenny. Derbyshire is celebrated for its mountains and minerals. The north of England is varied by hills, dales, and lakes. Here the scenery is rich and picturesque. Winander and Coniston *meres* (lakes) beautify Lancashire; Ulswater, the west of Westmorland; Bassenthwaite water, and Kesswick or Derwent-water, are situated in the south of Cumberland.

The atmosphere of England is humid, and hence the frequent changes of weather; but its constant agitation conduces to that perpetual verdure which covers the land, and preserves it from those extremes of heat and cold to which other countries in the same latitude are exposed.

The chief sea ports in England are London, which we have already noticed; Liverpool, the second port in the kingdom, trades principally with the West Indies, the East Indies, America, the Baltic, the Mediterranean, and Ireland. Bristol, next to Liverpool, trades with Ireland, the West Indies, North America, Hamburg, and the Baltic. Hull, reckoned the fourth port for commercial business, trades in coals, corn, wool, manufactured goods, with every country in Europe, with America, the West Indies, &c. Newcastle and Shields supply the London market with coals, and carry on some trade with the Baltic, and in the Greenland fisheries. Whitby builds many vessels, and has a good coasting trade; Gainsborough has some coasting, and a little foreign trade; Boston sends vessels to the Baltic, and exports oats to London; Lynn supplies most of the inland counties with coal, timber, and wine; it exports corn and malt, and partakes in the Greenland fishery. Yarmouth is a considerable sea port, and besides the coasting trade, sends ships to the Baltic, Holland, Portugal, and the Mediterranean. And the Thames, below London Bridge, is crowded with ships, which convey into that capital the commerce and wealth of the globe. Chatham, a great naval arsenal, is well defended by strong fortifications; as is also Portsmouth harbour, formed by the island of Portsea and the Peninsula. Southompton trades with France, Jersey, and Guernsey; and Plymouth, the most considerable harbour in England for a navy, has a good brisk trade in war time.

The chief manufacturing towns are Manchester for cotton goods, Leeds and Wakefield for woollen cloths, Birmingham and Sheffield for hardware and cutlery. Cornwall is the chosen depository of the metals. Wiltshire is famed for its superfine broad cloths.

Scotland.—The position of Scotland, the northern portion of Great Britain, has already been indicated. It is 260 miles long, and about 160 miles broad, at its greatest extremity. Its superficial contents are 27,793 square miles, the population 2,100,000 souls; consequently, there are nearly 72 inhabitants for every square mile. The established religion is the Presbyterian; but there are numerous dissenters.

Scotland is divided into thirty-three counties, as follow:

In the North are:

The Counties of,	*whose Chief Towns are,*
Orkney (Isles),	Kirkwall and Stromness.
Caithness,	Wick.
Sutherland,	Dornoch.
Ross,	Dingwall and Taine.
Cromarty,	Croamrty.
Inverness,	Inverness.

The Midland Division consists of,

Argyle,	Inverary.
Bute,	Rothsay.
Nairn,	Nairn.
Murray or Elgin,	Elgin.
Banff or Bamff,	Banff or Bamff.
Aberdeen,	Aberdeen.
Mearns or Kincardine,	Bervie.
Angus or Forfar,	Montrose.
Perth,	Perth.
Fife,	St. Andrew's.
Kinross,	Kinross.
Clackmannan,	Clackmannan.
Stirling,	Stirling.
Dumbarton.	Dumbarton.

In the South are:

The Counties of,	*whose Chief Towns are,*
West Lotnian or Linlithgow,	Linlithgow.
Mid Lothian or Edinburgh,	Edinburgh.
East Lothian or Haddington,	Haddington and Dunbar.
Berwick or Merse,	Dunse and Lauder.
Renfrew,	Renfrew.
Ayr,	Ayr.
Wigton or West Galloway,	Wigton.
Lanark or Clydesdale,	Glasgow and Lanark.
Peebles or Tweedale,	Peebles.
Selkirk,	Selkirk.
Roxburgh,	Jedburgh.
Dumfries,	Dumfries.
Kirkudbright or East Galloway,	Kirkudbright.

The Scottish isles are Bute and Arran in the Frith of Clyde; the Hebrides, west of Cantyre, are Ilay, Jura, Mull, Tiree, Col, Iona, Sky, Lewis, &c. The Orkney isles are separated from the main land by the Pentland Frith. They are twenty-six in number; but the chief is Pomona, or Mainland, and its principal towns Kirkwall and Stromness. The Shetland isles, north of the Orkneys, are forty-six in number; and of these twenty-six are inhabited. The chief town is Larwick.

The lakes and Friths of Scotland most noted, are, Loch Ness,—Loch Lochy,—Loch Lomond,—Loch Tay,—Loch Ave, and Loch Fyne.—The Frith of Dornock,—the Murray Frith,—the Frith of Tay,—the Frith of Forth,—the Solway Frith, and the Frith of Clyde.—A Frith is an arm of the sea, running up into the land; and the term loch, or lake, is applied indifferently to a piece of fresh-water, or an arm of the sea. Thus, Loch Lomond is a fresh water lake, and Loch Fyne an arm of the sea, like the Frith of Forth.

The principal mountains are, the Cheviot Hills, the Grampian Hills, Ben Nevis, in Invernesshire, 4350 feet above the level of the sea, and Ben Lomond, about 3200 feet high. From Ben Lomond a spectator sees Bute, Arran, the rock of Ailsa, Ireland, Pimlimmon in Wales, Skiddaw in Cumberland, &c.

The chief rivers are the Spey, in Invernesshire; the Deveron, separating Banff from Aberdeenshire; the Dee and the Don, intersecting Aberdeenshire from west to east; the Tay, falling into the German ocean below Dundee; the Forth, the most beautiful serpentine river, empties itself into the German ocean below Leith; the Tweed, at Berwick; the Annan falls into the Solway Frith at Annan; the Nith flows by Dumfries; and the Clyde, after washing Lanark, Renfrew, Dumbarton, Argyleshire, and Bute, empties itself into the Irish sea at the isles of Bute and Cumbras.

The canals of Scotland are those of Forth and Clyde, the Caledonian canal, a canal from Glasgow to Kilwinning; and one projected from Glasgow to Edinburgh. The Forth and Clyde canal extends from the mouth of the Carron and Forth to Dalmuir Burnfoot, six miles below Glasgow, and in its course, passes over several aqueducts, the chief of which is that of Kelvin, considered one of the finest pieces of masonry in the world. The Caledonian canal, 80 miles in length, opens a communication between the Murray Frith and the western sea, along a line of lakes, from Inverness by Fort Augustus and Fort William.

The surface and climate of Scotland, as contrasted with those of England, may be thus given:—The coast of Scotland is more checquered than that of England; and the former is more diversified by lakes than the latter. In the north, the mountains accumulate and precipitate the clouds in plentiful showers of rain; the air is therefore colder, the soil not so rich, and the harvests later than in England. The chief mountains here alluded to are the Grampian from Loch Lomond to the north-west of Aberdeenshire; and the Ochill hills, south of Perth.

The productions of the north of Scotland are cows, sheep, and horses, all small in size, but valuable to their owners. In the south and west, the horses and horned cattle are large and profitable; and the finest grays are bred in Ayrshire. The Highlands abound in timber and game; the western seas and lochs in cod, ling, salmon, and herrings.

The chief sea ports of Scotland, are Leith, Greenock, Glasgow, Ayr, Saltcoats, Kilwinning, Rothsay, Aberdeen, Dundee, &c. The chief manufacturing places are Glasgow, Paisley, Lanark, Kilmarnock, &c.

Ireland.—Ireland is an island in the Atlantic ocean, to the west of Great Britain. It is about 300 miles long, and 180 at its greatest breadth. Computing its superficial contents at 30,370 square miles, and its population at 5,000,000 of souls, there will be 164 inhabitants to each square mile.

Ireland is divided into four provinces:—*Leinster*, in the east, containing twelve counties. *Ulster*, in the north, containing nine counties. *Connaught*, in the west, containing five counties; and *Munster*, in the south, containing six counties.

The Counties of Leinster are:

County.	*Chief Towns.*	*Situate on the River*
Dublin	Dublin,	Liffey.
Louth,	Drogheda,	Boyne.
Wicklow,	Wicklow,	Irish Sea.
Wexford,	Wexford,	Slayney.
Longford,	Longford,	Shannon.
East Meath,	Trim,	Boyne.
West Meath,	Mullingar.	
King's County,	Philipstown.	
Queen's County,	Maryborough.	
Kilkenny,	Kilkenny,	Nore
Kildare,	Kildare,	
Carlow,	Carlow,	Barron.

The Counties of Ulster are:

Down,	Downpatrick,	Strangford Bay.
Armagh,	Armagh and Charlemont.	
Monaghan,	Monaghan.	
Cavan,	Cavan.	
Antrim,	Carrickfergus,	Bay of Carrickfergus
Londonderry,	Londonderry,	Foyle.
Tyrone,	Omagh.	
Fermanagh,	Enniskillen,	Loch Erne.
Donegal,	Lifford,	Foyle.

The Counties of Connaught are:

Leitrim,	Carrick on Shannon.	
Roscommon,	Roscommon.	
Mayo,	Castle Bar and Ballenrobe.	
Sligo,	Sligo,	Sligo Bay.
Galway,	Galway.	

The Counties of Munster are:

Clare,	Ennis.	
Cork,	Cork.	
Kerry,	Tralee.	
Limerick,	Limerick,	Shannon.
Tipperary,	Tipperary & Clonmel.	
Waterford,	Waterford,	Suir.

The established religion and ecclesiastical discipline of Ireland are the same as in England. But the prevailing religion is the Roman Catholic; and sectaries of various denominations are met with as in England.

There are four archbishopricks, *viz.* Armagh, Dublin, Cashel, and Tuam.

There are eighteen bishopricks, *viz.* Clogher, Clonfert, Cloyne, Cork, Derry, Down, Dromore, Elphin, Kildare, Killala, Kilmore, Killaloe, Leighlin, Limerick, Meath, Ossory, Raphoe, and Waterford.

There is only one University in Ireland, namely, that of Dublin; the Royal College of Maynooth is for the education of young men of the Roman Catholic religion.

The chief cities are Dublin, the capital, about ten miles in circumference, containing 120,000 inhabitants; Cork, the second city, has a population of 80,000 inhabitants, and is the grand market of Irish provisions; Limerick, the third city, containing 60,000 inhabitants, exports beef, hides, tallow, and butter. Waterford has 35,000 inhabitants, and exports similar commodities. Galway carries on a trade with the West Indies; Sligo is an increasing town, and Castlebar is also prosperous. Londonderry is not so famous for its commerce as for its ancient and military fame. But Belfast, originally a Scottish colony, now boasts a population of 20,000 people, employed in the manufacture of cotton, cambric, sail-cloth, linen, white glass, sugar, and earthenware. Dundalk manufactures linens and muslins; Drogheda exports grain; and Wexford is noted for its woollen manufactories.

A canal joins Dublin by an inland navigation with Limerick and Waterford; and there is another canal from Newry to Loch Neagh. The principal rivers are, the Shannon, the Suir, the Blackwater, the Bann, and the Liffey. And the chief lakes are, Loch Erne, Loch Neagh, Loch Corrib, Loch Rea, and Loch Derg.

The climate of Ireland is mild, and favourable to vegetation. And the face of the country is more level, fertile, and abundant in pasturage than Scotland. But the farmers are oppressed by speculators, called *middle men*, who rent farms from the landlords, and let them to the real occupiers; these last suffer equally with the proprietors, from this shocking system.

Among the natural curiosities of Ireland, we must not omit the picturesque Lake of Killarney; the Isle of Innisfallen, venerable and romantic; and the Giants' Causeway, 600 feet in length, and from 120 to 240 feet in breadth, and from sixteen to thirty-six feet above the level of the strand. This causeway, which is situated about eight miles north-east from Coleraine, consists of many thousand pillars, mostly in a vertical position, some high, others broken, but in general, sufficiently level to form a pavement projecting into the sea to an extent unknown to man.

The isles belonging to Ireland, are Lambey, north-east of Dublin; at the south-eastern extremity appear the Saltee isles and the rocks of Tashard; Clare, at the southern extremity, is chiefly famed for its promontory, Cape Clear. The Hog Islands, the Skellegs, Valentia, and the Blaskets, are on the north-west, and off the coast of Kerry. The South Arran Isles lie in the Bay of Galway, and the islands of North Arran are off the coast of Donegal.

Sweden, Lapland, and Norway.—Sweden, on the north-west of Europe, is 1150 miles in length, and from the Norwegian Alps to the limits of Russia, about 600 miles in breadth. The contents in square miles are 208,912, and the inhabitants being reckoned 3,000,000, there will be 14 to every square mile.

Sweden is divided into several provinces, *viz.* Sweden proper, West Norland, Swedish Lapland, East Bothnia, Finland, and Norway.

The established religion is Lutheran. There are one archbishopric, thirteen prelacies, and 2537 parishes. The priests are in number 1378, with 134 vicars, and 192 inspectors.

The government is absolute monarchy; and the diet, or parliament, consists of nobles, landed gentlemen, clergy, burgesses or deputies of towns, and those of the peasantry.

Sweden possesses only one colonial possession, the island of St. Bartholomew in the West Indies. Its army is about 48,000 men; and its navy about twenty ships of the line. The revenue about £1,500,000; the national debt £10,000,000 sterling.

In their manners, the Swedes affect the politeness and frivolities of the French; the men are commonly robust, the women slender and elegant.

The Universities are those of Upsal, containing about 500 students; Lunden, 300; and Abo, equalling that of Upsal.

The chief towns are Stockholm, the capital, built on seven small islands, and resembling Venice, but with greater diversity of prospect, and scenery more truly singular and romantic. Upsal, the only archbishopric, contains about 3000 inhabitants, exclusive of the students. Gothenburgh, in West Gothland, has 20,000 inhabitants, and carries on considerable commerce, and a brisk herring fishery.

Carlskrona, founded by Charles XI. in 1680, contains about 11,000 inhabitants; and Abo, in Finland, 8750.

Sweden manufactures iron and steel, copper and brass, cloths, hats, watches, and sail cloths. The miners amount to 25,600.

The great forests of Sweden and Norway consist chiefly of pine and fir, spruce fir; the former is called the *red*, the latter the *white* wood of commerce.

The winter maintains a lengthened and dreary sway in the north of Sweden; and the gulf of Bothnia becomes one vast field of ice. In the south, Sweden resembles Scotland in temperature of climate. In the north, on the other hand, in the summer, the climate is hot, from the great length of the days, and the reflection of the sun's rays from the numerous mountains; for at Tornea, in Swedish Lapland, the sun never sets for some weeks together. The Aurora Borealis sheds its ruddy light through the sky, and cheers the darkness of the winter.

Sweden is more diversified than any country of Europe except Switzerland: extensive lakes, large pellucid rivers, winding streams, foaming cataracts, gloomy forests, verdant vales, and rocks piled on rocks, on all hands greet the traveller.

The Swedish rivers are numerous, on account of the lakes and mountains. The chief are the Elfs, the Gotha, the Motalo, the Dahl, and the Bothnia. The lakes are those of Wener, Weter, Meler, Hielmar, Stor, Enara, Hernarba Staer, or the great lake, Tornea, and the Pajana in Finland, eighty miles in length, and fourteen miles in breadth.

The chief mountains are those which divide Sweden and Swedish Lapland from Norway; and from these, successive ranges diverge in a south-east direction. The centre of this chain, like that of the Pyrenees, is the loftiest part, and it declines towards Lapland.

There are few species of trees in Sweden beside the fir, the mountain ash, the alder, the birch, and the willow; but in the south, the lime, the elm, the ash, and the oak flourish. And the inner bark of the fir, mixed with rye-meal, furnishes to the poor a coarse bread in time of scarcity.

The Swedish horses are small, but of good mettle. The bear, the lynx, the wolf, the beaver, the otter, the glutton, the flying squirrel, the rein-deer, falcons, eagles, ducks, geese, and an infinite variety of game, are found in Sweden, and Swedish Lapland.

The mines of Sweden are the grandest in Europe; as, the *gold* mines of Adelfors, in the province of Smoland; the *silver* mines of Salberg, thirty miles west of Upsal; the *copper* mine in Delecarlia; the *iron* mines of Danamora; and an entire mountain of iron ore, near Tornea, in Lapland.

The Swedish islands in the Baltic are, Rugen, Oeland, Gothland, and the isles of Aland, at the entrance of the Gulf of Bothnia.

Norway.—Norway, ceded to Sweden by Denmark, in lieu of Pomerania, is divided into Christiansand, Aggerhaus, Bergen, Drontheim, Norland, and Finmark. The population is estimated at 700,000, and has remained pure and unmixed by conquests; hence, the Norwegians, the descendants of the ancient Fins and Laps, still retain the muscular frame, the fresh countenance, and the yellow or red hair of the Normans. The *Peasantry* are frank without ostentation, and undaunted without insolence. Their ordinary dress is grey, with red buttonholes, and white metal buttons; and the women dress in a petticoat and shift, with a close collar round their throat, and a black sash. The *Laplanders*, or Norwegians of Finmark or Lapmark, are of a small size, generally about four feet, with large heads, high cheek-bones, swarthy complexions, wide mouth and thick lips, dark eyes, and short black hair. Their usual dresses are red caps lined with fur, and robes of cloth or skin.

The religion of Norway is the Lutheran, and there are four bishoprics. The parochial clergy are maintained by their glebes, tithes, and surplice fees.

In *Lapland*, the sun is absent for seven weeks at a time; but the stars are then visible, and from ten to one in the day time there is a kind of twilight, by which a person may see to read without artificial light.

There are four grammar schools in Norway, and a special seminary for the Laplanders at Bergen.

The chief towns of Norway are Bergen, the capital, containing a population of 19,000 souls; Christiana, with a population of 10,000 inhabitants; and Drontheim, the ancient residence of the kings of Norway, 8,000 souls. The chief products of Norway are wood, goats' hides, silver, copper, iron, &c.

Though the most mountainous country in the world, Norway boasts a salubrious atmosphere; its inhabitants, in general, attain a good old age; and though the weather in winter is cold, the harbours are seldom frozen. The highest land is 2,655 feet above the level of the sea; the loftiest vale, 2,000 feet; and the pine grows at an elevation of 3,000 feet.

The chief river in Norway is the Glomen, full of cataracts and shoals; yet 50,000 trees are annually floated down its stream to Frederickstadt. Next in consequence is the Dramme, then the Louven, the Torrisdals, the Tana, and the Alten. The lakes are those of Mioss, Rands, Tyri, and Foemund. The first is sixty miles long, the second fifty, but not more than two in breadth, the third is fifteen miles long, and exhibits an enchanting picture of bays and creeks, diversified by corn-fields, fertile meadows, and hanging forests; and the last is thirty-five miles long and eight broad. The Maelstroom, a whirlpool on the sea-shore of Norland, proves dangerous to boats, and even to the majestic whale.

The Danish Dominions.—The kingdom of *Denmark* consists of Zealand, Holstein, Lunenberg, Jutland, Iceland, and the Feroe Islands. Zealand is an island at the entrance of the Baltic; Holstein and Lunenberg border on Germany; Jutland is a tongue of land projecting from the continent at Holstein; Iceland is a large island in the Arctic Ocean; and the Feroe Islands lie north-west of Shetland.

The established religion is the Lutheran; and in Denmark proper there are six bishoprics, and two in Iceland. The chief see is that of Zealand, which yields about £1,000 per annum. The parochial clergy are maintained by their glebes, tithes, and surplice fees. In Jutland, however, some of the livings do not exceed £20 a year. The government is absolute monarchy, but exercised with mildness.

The population is about two millions and a half, the square contents of territory 180,000 miles, therefore there are twelve inhabitants to a square mile. The army is about 70,000 men. The revenue of Denmark is £543,554; Sleswick and Holstein, £300,000; the West India islands, £262,000; the customs at the Sound, £122,554; Altona, £3,150. The maintenance of the government amounts to £1,050,000. The national debt is £2,600,000.

The colonial possessions are Tranquebar, on the coast of Coromandel; Christianburgh, on the coast of Guinea; a small part of Greenland; St. Jan, St. Thomas, and St. Croix, in the West Indies.

The Danish peasantry are vassals, idle, dirty, and dispirited; but the superior classes differ little from their neighbours on the continent of Europe. Every parish of Denmark is provided with two or three schools; and the masters teach the youth their native language, writing, and arithmetic. But in Holstein there are sixteen grammar schools, eleven in Sleswick, and nineteen in Jutland or Denmark proper, maintained at the royal expense. The universities are those of Copenhagen and Kiel.

The chief cities are Copenhagen, the capital, in the island of Zealand, with 90,000 inhabitants; and Altona on the Elbe, close to Hamburgh, with a population of 25,000 inhabitants. At Elsinore, all foreign ships entering the Baltic, pay a toll or custom-due. The canal of Kiel, twenty miles in length, unites the Baltic with the Eyder, which falls into the German sea.

Denmark *exports* corn, horses, and black cattle; butter, fish, tallow, hides, oil, tar, pitch, resin, and timber; and it *imports* silks, broad cloths, wine, brandy, salt, furniture, and colonial produce.

The soil of Jutland and Holstein resembles that of England; and the process of agriculture is excellent in the south.

The chief river is the Eydar, the ancient boundary between Denmark and Germany. In Denmark proper, there are some hills and forests, but no mountains.

Iceland is 260 miles long, 200 broad, and contains 50,000 inhabitants. This island is famous for its volcanic mount Hecla, its boiling springs, sulphureous rivers, and the literature of its natives.

The Feroe Islands, seventeen in number, have a population of 5,000; but though not unfertile, their products are scanty; and they are chiefly famed for many singular ranges of basaltic columns.

The Russian Empire.—Russia is the most extensive empire in the world; its length being 9,200 miles, its breadth 2,400 miles, and its superficial contents 1,200,000 square miles. Its entire population is fifty millions of inhabitants, thousands of whom are mere barbarians and savages.

Its religion is the Greek Church; the clergy are 67,000, and are exempt from taxes. There are thirty bishoprics, 18,350 cathedrals and parish churches in this empire; the monasteries are 480; the monks 7,300; the nunneries 741, and the nuns 3,000.

The government is a military despotism; the laws, the will of the emperor; and the provinces are managed by viceroys.

The greater part of the peasantry or boors are serfs or slaves; and in the bank belonging to the government, a slave was wont to be taken in pawn for forty roubles!

The chief colonies of Russia are on the eastern coast of the Asiatic continent; her army is immense, but her navy inconsiderable; the revenue is not above £12,000,000; but there is hardly any national debt.

The manners and customs of the Russians are as various as their distinct countries or races; and may be viewed as those of the Laplander, the Tartar, the Asiatic, the Parisian, and the Pole.

The chief towns are Moscow, Petersburgh, Archangel, Tobolsk, Irkutsk, Revel, Astracau, Cherson, Smolensko, &c. Moscow contained 1,000 places of public worship, before it was burned in 1812, and its public buildings were the most magnificent in Europe. Petersburgh boasts an extensive commerce; Cherson is the chief mart in the south of Russia; and Astracan carries on much trade with Persia and India.

Russia has an extensive inland navigation of 2,400 miles, between the Baltic and Caspian seas. Its manufactures are carried on with spirit, prosperity, and profit; and its internal and foreign commerce is very considerable. The climate of Russia is various, on account of its great extent, both north and south. In the north, the winters are intensely cold; in the south, they are mild; and summer in both is warm and genial. The soil is various, pasturage is abundant, and though the harvests are plentiful, agriculture is conducted with great negligence. The rivers of Russia are numerous, and generally on a grand scale; as, for instance, the Volga, the sovereign of European rivers; the Don or Tanais; the Neiper or ancient Boristhenes; the Dwina; the Bog, or Hypanis; the Niester; the Narva; the Duna; and the Niemen. The lakes are those of Imandra, in Russian Lapland; Onega, 150 miles long and thirty broad, and Ladoga, 130 miles long, and thirty broad, in the government of Onetz; the lake Peypus, sixty miles long by thirty broad; the lake Ilmen; the Beilo, or White Lake; and the Seliger, in the government of Tver.

The mountains are those of Olonetz and Ural, which separate Europe from Asia. But in general, Russia is a desert and level country.

The animals peculiar to Russia are bears, wolves, lynxes, elks, camels, horses, sheep, reindeer, poultry, game, &c. The mines are chiefly iron ore, at Dougna, near Smolensk; but in the Uralian mountains gold has been discovered.

Among the natural curiosities, the grotto of Kurgur, on the western side of the Uralian mountains, is of great extent, containing many subterraneous lakes and meadows. The icebergs which float in the Arctic Ocean reflect all the colours of the rainbow, and seem so many cathedrals of crystal, adorned with silver pinnacles.

The chief islands belonging to Russia, are Cronstadt, in the Gulf of Finland; Oesel and Dago, in the Baltic, peopled by Estonians, or Livonians; Nova Zembla, in the White Sea; Spitzbergen; the dreary group of isles called the Seven Sisters; the Kamtschadale Islands, comprising the Kurile Isles, the Aleutian Islands, and the Renaiski group.

Prussia.—Prussia dates its consequence as a kingdom among the states of Europe, at the commencement of the 18th century. Its acquisition of territory since 1814, has been considerably increased by Russia and Great Britain, that the balance of power might be more advantageously distributed between the north and the south of Europe. The extent of Prussia is now about 600 miles long by 300 broad; and it comprehends the following

Divisions.	*Towns.*	*Rivers.*
1. The Kingdom of Prussia,	Konigsburg,	Pregal,
2. Polish, or Western Russia,	Dantzic,	Vistula,
3. Part of Silesia,	Breslaw,	Oder,
4. Electorate of Brandenburg,	Berlin,	Spree,
5. Part of Pomerania,	Stettin,	Oder,
6. Part of Lower Saxony,	Magdeburg,	Elbe,
7. Part of Westphalia.	Embden.	Ems.

The population is estimated at nine millions; and in their manners and customs, the Prussians resemble their German neighbours They are, in general, industrious, honest, and brave.

The religion is Protestant, under the two divisions of Lutheran and Calvinistic; though by its recent acquisitions Prussia has now many Roman Catholic subjects. The power of the clergy is inconsiderable. The government approaches a military despotism, supported by an army of 200,000 troops; and the perpetual supply of recruits for this force, creating a constant uncertainty of destination for life, impedes greatly the national education. The universities are those of Frankfort on the Oder; Konigsberg and Pasna or Pasen. The chief towns are Berlin, the capital, containing a population of 142,000 inhabitants; Konigsberg, 50,000; Breslaw, the capital of Silesia; Brandenburg; Frankfort on the Oder; Magdeburg; Neufchatel; Stettin, and Thorn.

The manufactures of Prussia are chiefly glass, iron, brass, paper, woollen cloth, and silk, mostly for home consumption; and the exports are timber, corn, tallow, skins, leather, flax, hemp, and linens, which pass for Dutch manufacture.

In general the climate of Prussia is cold and moist; and the lower parts of Silesia are the most healthy. Though Prussia proper is fertile, the whole district, from Berlin to Potsdam, resembles a wilderness; and the peasantry are oppressed by taxation and levies for the army.

The chief rivers are the Elbe, the Spree, the Havel, the Oder, the Vistula, the Pregal, and the Memel. The lakes are the Spelding-See, and the estuaries of the Oder, the Vistula, and the Memel, called respectively the Grass Haff, the Frisce Haff, and the Curische Haff. The mountains are chiefly situated in Silesia, and may be considered as northern branches of the Carpathian, yet in the north-west part of Silesia, the Spitsberg and Graftzberg are detached mountains, somewhat less elevated than the Carpathian chain.

Silesia, bordering Hungary, presents continuous forests; and the forest of Masavia, not far from Warsaw, is a famous haunt of the Urus, or wild cattle of Lithuania. Prussia possesses some iron founderies; coal is found in Silesia; and the Samland shore of the Baltic is the repository of amber.

Germany.—Germany is situated in the middle of Europe; its length is 600, and its breadth 500 miles. This country is chiefly remarkable for its political subdivisions into electorates, grand duchies, duchies, marquisates, principalities, bishoprics, and free cities. These are all independent states united by a political tie, under the title of the *Germanic Confederation.*

The commonly received division of Germany is into nine parts, called circles; namely,

Three Northern.	*Three Middle.*	*Three Southern.*
Westphalia,	Lower Rhine,	Swabia,
Lower Saxony,	Upper Rhine,	Bavaria,
Upper Saxony,	Franconia,	Austria.

Note.—These circles are again subdivided into principalities, electorates, &c. among more than 200 independent princes; but Lubeck, Frankfort, Bremen, and Hamburg, are sovereign states, governed by their own magistrates.

The climate of Germany is temperate, inclined rather to cold than heat, and the soil is rich and fertile both for corn and pasture.

In their character the Germans are open and free; inured to labour, they are dexterous in manufactures, fruitful in inventions, and when called into the army make good soldiers. The population is twenty-five millions, and the army 400,000 contingent troops.

The religion of north Germany is the Reformed or Protestant, while in the south the Roman Catholic faith prevails. And the government is aristocratical, but its chief magistrate may be of the Catholic, the Lutheran, or the Calvinistic faith.

The chief rivers are the Elbe, the Weser, the Rhine, and the Danube. The chief towns are Dresden, Meissen, Wittenburg, Magdeburg, and Hamburg, on the banks of the Elbe; Bevern, Minden, and Bremen, on the banks of the Weser; Dusseldorf, Coblentz, Heidelberg, on the Rhine; Ulm, Neuburg, Ratisbon, Passau, Vienna, and Presburg, on the Danube; Munich, Prague, Stutgard, and Frankfort.

The chief lakes are those of Plau, in the duchy of Mecklenburg; the Baden-See, or lake of Constance; and the Chiem-See, in Upper Bavaria. The mountains are those of the Hartz, forming a fine amphitheatre, 3000 feet high at the great Broken, its greatest ridge; the Minden Hills in Westphalia; the Erzgeberg, or Metallic Mountain, extending between Bohemia and Saxony, and supplying silver, tin, and other metals; the mountains of the Black Forest; the Tyrolese Alps; and the Carpathian chain. The Dromling-wald (forest) is to the north of Magdeburg; the Sollinge-wald, are the woody mountains of the Hartz; the Lutten-wald is the Thuringian forest; in the south is the forest of Spessart; the Black Forest is south of the Mayn in Swabia. The oak is the prevailing tree in all these forests; and the wild boar feeds on its fruit.

The chief German states on the north of the Mayn, are Saxony, Brunswick, Lunenburg, Hessia, Mecklenburg, the duchy of Brunswick, the city of Hamburg, some smaller states, and the ecclesiastical powers.

Saxony.—In this division the Elector of Saxony is the chief potentate, and his dominions, (which include Saxony proper, Voigtland, in the south; Lusatia, in the east; a part of Thuringia, in the west; and a part of Misnia and Heneberg,) extend from east to west 200 miles, and from north to south about 130 miles.

The religion of Saxony is the Protestant; the bishoprics are Merseberg and Naumberg; the sovereign can issue no laws without the consent of the nobles, the clergy, and the burgesses, who assemble sextennially to regulate the taxes and imposts; the army is computed at 24,000 men.

The chief cities are Leipsic, the celebrated mart of German literature, with a population of 30,000 inhabitants; and Dresden, with a population of 50,000 inhabitants. The chief manufactures are thread, linen, laces, ribbons, velvets, carpets, paper, colours, glass, and porcelain.

Saxony is famous for its tin, copper, lead, iron, and silver mines; and its agricultural products are both numerous and plentiful. Indeed, the country between Meissen and Dresden rivals the north of Italy, and many parts of Germany are indebted to it for hops, flax, hemp, tobacco, saffron, madder, and wine.

The Kingdom of Hanover.—The electorate of Brunswick Lunenberg, or Hanover, has been erected into a kingdom dependent on Great Britain, since the peace of Paris in 1814. This electorate comprises Luneberg, Bremen, Verden, and Saxe Lunenberg, adjacent to Holstein, on the north bank of the Elbe. In the south it has Calenburg, and Grubenhagen; in the west Diepholtz and Hoya; and Danneberg in the east. Its length is 180 miles from east to west, and about 100 from north to south.

The religion is Lutheran, and the government is conducted by a council of regency, appointed by the king of Great Britain.

The chief towns are Hanover, containing about 16,000 inhabitants; Gottingen, 7,600 souls; Verden, Luneburg, Lunenburg, Zell, Einbeck, and Osterode. The manufactures are linen, cotton, and broad cloths; the exports, metals, linens, timber, cattle, and grain; the agricultural products are wheat, rye, barley, oats, peas, haricots, flax, hemp, tobacco, madder, fruits, potatoes, &c.

The chief rivers are the Elbe, the Weser, the Leina, the Aller, the Ilmenau, and the small streams of Loha, Lutter, Fuse, and Siber; and there are a few small lakes, as those of Dieplwitz and Stinhudder; but the forests, though numerous, are not extensive.

The bishoprick of Osnabruck, in Westphalia, is considered an appendage of Hanover. A prince of the house of Hanover exercises the civil and criminal, and the archbishop of Cologne, the spiritual superiority, of the bishopric of Osnabruck, whose inhabitants are computed at 120,000 souls, and its revenue at £26,250 sterling.

Hesse Cassel.—Hessia, or Hesse Cassel, is about eighty miles long, and about the same in breadth. Its inhabitants are about 750,000 souls; and its military force has amounted to 12,000 men. It abounds in game and fish, fossils and minerals; silver, copper, lead, fine clays, marble, and alabaster are also found; and the vales are diversified with vineyards and fields, fertile in corn and pasturage, and watered by the Rhine, the Mayn, and numerous smaller rivers.

The religion is the Reformed; and there are three orders of the state, nobles, clergy, and burgesses, from Cassel, Marburg, and some other towns. The universities are those of Marburg, Rintelin, and Giessen. Cassel contains about 22,000 inhabitants; the county of Hanau about 100,000 souls.

The Duchy of Mecklenburg.—The duchy of Mecklenburg contains 4,800 square miles, peopled by 375,000 inhabitants. It is divided into Schiverin and Gustro, celebrated for their lakes, heaths, and marshes, with a sandy soil that produces only rye and oats. The religion is Lutheran, with six superintendants and an university at Rostock. The taxation is regulated by the states, consisting of the nobility and burgesses. The manufactures are chiefly wool and tobacco; the exports by Lubec and Hamburg, are grain, flax, hemp, hops, wax, honey, cattle, butter, cheese, fruits, feathers, dried geese, tallow, linseed, wool, and timber.

Hamburg.—Hamburg, the third city of Germany, contains 100,000 inhabitants, who are ruled by an aristocratic senate of thirty-seven persons. The religion is the Lutheran. Its trade lies in linen and woollen cloth, wines and sugars, coffee, spiceries, metals, tobacco, timber, leather, corn, dried fish, and furs.

The Principality of Oldenburg, &c.—The principality of Oldenburg has 75,000 inhabitants; Pomerania, now the property of Denmark, 100,000; the principality of Anhalt, about 100,000; Nassau, 130,000; Schwartzburg in Thuringia, 100,000; Waldeck, 80,000; the county of Lippe in Westphalia, 95,000; the county of Reuss, 66,000; Frankfort on the Mayn, 36,000; and the town of Papenburg, with its 3000 souls, in East Friesland, belongs to the Baron of Landsberg Velen.

The Ecclesiastical States, &c.—The ecclesiastical states are, 1. The elector of Mentz, who holds the city of Erfurth, and 15,000 inhabitants. 2. The elector of Triers, or Treves. 3. The elector of Cologne. 4. The bishoprics of Munster, Osnabruck, Paderborn in Westphalia, and Liege. 5. The bishopric of Hildesheim, in Lower Saxony. 6. Of Fulda, in the Upper Rhine: and, 7. Wurtzburg, in Franconia. The ecclesiastical electorates contain a population of 300,000 inhabitants; the bishoprics average from 70,000 to 200,000 each.

The German states south of the Mayn, are, the electorate of Bavaria, conjoined with the Palatinate, the duchy of Wirtemberg, those of Anspach and Salzia, with the smaller states and the ecclesiastical powers. The preponderating powers in the south of Germany, are Bavaria and Wirtemberg; now erected into kingdoms.

The Kingdom of Bavaria.—The kingdom of Bavaria is divided into Upper and Lower, and what is called the Higher Palatinate; the first is a mountainous country, the second champaign and fertile; but, in general, the country is woody, interspersed with lakes of various sizes. The religion is Catholic; the inhabitants about two millions; the revenue £1,166,600; the military force about 15,000 men. The chief rivers are the Danube, the Inn, the Iser, the Lech, the Nab, and the Neckar. Munich, the capital, is the most elegant city of Germany, and its population amounts to 38,000 souls. Landshut and Strauben are in Lower Bavaria; Ratisbon is an imperial city; Manheim, in the Palatinate of the Rhine, contains 24,000 inhabitants; and Heidelburg is famous for its wines. The states, or parliaments, are composed of the clergy, nobility, and burgesses. The only college is at Ingolstadt, but Munich has an academy of sciences.

The Kingdom of Wirtemburg.—The kingdom of Wirtemburg contains about 600,000 inhabitants, and next to Saxony, is the best in the empire, being by far the most considerable and fertile part of the circle of Swabia. The Black Forest supplies it with timber and fuel, and the castle of Wirtemburg, in the bailliage of Canstadt, gives name to the kingdom. The religion is Lutheran, and the church is ruled by four superintendants, called abbots, and thirty-eight rural deans. The chief city is Stutgard; and Zubingen, the second city, is celebrated for its university.

Minor States.—Anspach, or Onolsbach, with Bayreuth, has a population of 320,000, on 2,300 square miles of territory. The principality of Bayreuth, or Culmbach, with Onolsbach, forms the chief power of Franconia, now annexed to the sovereignty of Prussia.

The margraviate of Baden, situated between the Rhine and the kingdom of Wirtemburg, is fertile in wine, corn, and fruit, and has abundance of fish, wood, and game. The population is estimated at 200,000 inhabitants; and the city of Nuremberg contains 30,000 souls.

Salzia, and the archbishopric of Saltzburg, possesses a population of 250,000 souls, peopling 2,880 square miles. This see was founded in 716, by St. Rupert, an Englishman, and the archbishop is primate of all Germany.

Saltzburg has 20,000 inhabitants, and the archbishopric sways many fair lordships in Austria, Stiria, and Carinthia. The sees south of the Mayn, are: 1. The archbishopric of Saltzburg. 2. The bishopric of Wurtzburg. 3. Bramburg, containing 180,000 souls. 4. Speyr, or Spire, 50,000 inhabitants. 5. Aichstett, in the southern corner of Franconia. 6. Augsburg, in Suabia. 7. Constance. 8. Strasburg. 9. Kemptin, Buchau, and Lindau, Abatial territories; with the priory of Ellsvangen. 10. The bishopric of Passau, in Bavaria, with a population of 25,000. 11. That of Freysingen, with the territory of Wendenfels, near the Rhaetian Alps, contains 23,000 souls: and 12. The bishopric of Ratisbon.

Austria.—The Austrian dominions border those of Russia and Turkey on the east; Prussia, Upper Saxony, Bavaria, and Swabia, bound them on the north; Swisserland, and the Italian states, skirt their southern limits. In length 760, in breadth 520 miles. The contents in square miles are 184,000; and there are 184 inhabitants to every square mile. Venetian Dalmatia, and some Italian territory, has fallen to the lot of Austria, whose population is now about 30,000,000. The Austrian dominions comprehend:

		Chief Towns.	*Rivers.*
1. The circle of Austria, including	The Archduchy of Austria,	Vienna,	Danube.
	Duchy of Stiria,	Gratz,	Muchr.
	——— Carniola,	Laybach,	Laybach.
	——— Carinthia,	Clagenfurt,	Glan.
2. The kingdom of Bohemia,		Prague,	Danube.
3. Moravia,		Olmutz and Brunn.	
4. Part of Silesia,		Troppau,	Oppa.
5. Part of Bavaria, east of the Inn.			
6. Hungary, including	Upper Hungary,	Presburg,	Danube.
	Lower Hungary,	Buda, or Offen,	
	Sclavonia,	Eszeg,	Drave.
	Croatia,	Carlstadt,	Culp,
7. Transylvania,		Hermanstadt.	
8. Part of Poland, bordered by the river Bug,	Galitzia	Lamburg, or Leopold,	Bug.
	Lodominia,	Cracow,	Vistula.

The established religion is the Roman Catholic, but the government is exceedingly tolerant of all religious persuasions; for, in Moravia and Bohemia, Protestants of various sects abound; and the Lutherans are little inferior in number to the Romanists. The government is absolute monarchy, supported by an enormous military force of above 300,000 men. The revenue is computed at 10,000,000 sterling, and the national debt at 40,000,000 sterling. The Austrians are reserved, but civil; and their women, though elegant in their manners, are destitute of those mental accomplishments which give the females of France and Britain such an ascendancy.

Hungary has an aristocratical senate; and Austria its states, consisting of the four orders of clergy, peers, knights, and burgesses. The laws are, however, mild and salutary; but while the Austrians live contented, the Hungarians are too often dissatisfied with their masters, and disposed to anarchy. The universities are those of Vienna, Prague, Inspruck, Gratz, Buda, Debretzin, and Erlau.

The chief cities and towns are, Vienna, the capital of the Austrian dominions, on the south, or rather the west side of the Danube, containing about 254,000 inhabitants; Prague, the capital of Bohemia, containing 80,000; Gratz, the capital of Stiria, 35,000 souls; Presburg, the capital of Hungary, 270,000 inhabitants; Buda, 20,000; Lemberg, or Leopold, in Poland, 20 000; Cracow, the ancient capital of Poland, 24,000; Brun, in Moravia, 18,000; Olmutz, in the same country, 12,000; Troppau, in Austrian-Silesia, 12,000; Inspruck and Trent, each, 10,000; and Trieste, 18,000.

The climate of Austria is mild and salubrious; but the air of Hungary is damp and cold, from numerous lakes and morasses. The general outline of the Austrian territory is finely variegated, and sufficiently irrigated for every species of European vegetable product. And the soil is fertile and productive, notwithstanding the general neglect of agriculture.

The chief rivers are the Elbe, the Danube; the Tiess, which falls into the Danube near Belgrade; the Save, which forms the boundary between Austria and Turkey; the Drave, which joins the Danube below Eszeg; and the Inn, which joins the Danube at Passau. The Raab and the Leytha are intermediate streams between the Drave and the Inn. The Mulda joins the Elbe near Melnich; and the Moran joins the Danube not far from Proeoburg. The principal lakes are those of Traun and Ebernsee, in Austria Proper; Clagenfurt, in Carinthia; the Cirknitz-see, in Carniola; the Platten-see, in Hungary, abounding with fish; the Neusidler, in the vicinity of Eisenstadt; Palitzen, on the east of the Tiess; and the Tsege Zo, in Transylvania. The lake of Cirknitz is a complete natural curiosity, eight miles long by four broad. In the month of June, the water descends under ground, through numerous crevices in the bottom; but in September it again reascends with considerable violence, thus yielding rich pasturage in summer, and an abundance of fish in winter.

The chief mountains are, the Rhaetian, or Tyrolese Alps; the Brenner mountains, or Rhaetian Alps; the glaciers of Verner, west and north of Inspruck; the Lobel mountains, which separate Carinthia and Carniola; and the Julian, or Carnic Alps, which divide Carinthia from Italy. The Carpathian mountains, 900 feet high, which bound Hungary on the north and east; and the Sudetic chain, which, branching from the Carpathian, divides Bohemia and Moravia from Silesia, and the Prussian dominions.

The forests in Austria are both numerous and extensive, clad with elm, lime, birch, and alder trees; oak, chestnut, and beech trees; the black and white poplar, and aspen; sycamores and maples; the ash, the pine, the fir, and the larch. Horses run wild in these forests; the cattle are of a slaty-blue colour; the Hungarian sheep have long erect spiral horns, and hairy fleeces. The urus, or bison, ranges the forests of Carpathia; the bear, the boar, the wolf, the chamois, the marmot, and the beaver, are among the numerous wild quadrupeds.

The Kingdom of the Netherlands.—This kingdom, comprising Holland and the Low Countries, was erected into a sovereignty, by the treaty of Vienna, in 1815. Holland is composed of seven provinces, called after the following names, with their chief towns:

The Provinces of	*Chief Towns and Rivers.*
Holland, ...	Amsterdam, and the Hague.
Overyssel, ...	Derventer, on the river Yssel, and Zwoll on the river Aa.
Zealand, ...	Middleburg, on the isle of Walcheren.
Friesland, ...	Leewarden canal.
Utrecht, ...	Utrecht, on the Rhine.
Groningen, ...	Groningen canal.
Guelderland, ...	Arnheim, on the Rhine.
Zutphen, ...	Zutphen, on the Yssel.

These provinces, with the Netherlands, and the duchy of Luxemburg, comprise the most fertile countries in Europe, inhabited by 7,000,000 of wealthy and industrious people. The Dutch, like all plain-dealing people, are ceremonious, rather than polite; and in distinction to a Parisian the Hollander seems to say, "I would rather be unmannerly than troublesome."

The Protestant-Calvinistic religion prevails in Holland; but in the Netherlands there are numerous Roman Catholic families; and there are not a few Lutherans and Jews to be met with. The colonies are situate in the East and West Indies, and at the Cape of Good Hope. The army may be computed at 60,000 troops in war-time, and the navy once amounted to about forty ships of the line.

At Rotterdam, Breda, Middleburg, and Groningen, there are very celebrated Latin schools; Leyden, Utrecht, Harderwyck, Tranecker, and Groningen, are famous for their universities; Amsterdam and Deventer have two inferior colleges; and Haerlem is noted for its academy of sciences. The chief cities and towns are, Amsterdam, whose population amounts to

212,000 souls, and its haven is one forest of masts; Leyden, containing 50,000 inhabitants; Rotterdam, 48,000; Haerlem, 40,000; the Hague, though esteemed only a village, 36,000; Middleburg, in Zealand, 30,000; and Utrecht, Delft, Dort, and Groningen, each about 20,000 inhabitants.

No country in Europe boasts an equal inland navigation with Holland; a circumstance easily accounted for by the fact, that the land is almost every where lower than the sea, which is kept out by dams and dykes. A country so low, and from its abundant inland navigation so level, must, of necessity, possess a humid and cold climate; and where the combination of land and water, with scanty elevations of barren sand, is very intimate, we cannot expect that agriculture will be considerable, though the pasturage may be rich, and even abundant. Hence Holland is the country for the manufacture of butter; and so scrupulous are the good women about their cows' warmth and cleanliness, that it is no uncommon thing to see whole herds in the meadows clothed with mantles and coverlets.

The chief rivers are the Rhine and the Meuse; and the chief lake is the sea of Haerlem.

Flanders, an integral part of the kingdom of the Netherlands, is about 180 miles long, reckoning from the eastern limit of Luxembourg to Ostend, and 120 in breadth, from the northern boundary of Austrian Brabant to the most southern limit of Hainault; covering a surface of 7,520 square miles, and peopled by 1,900,000 inhabitants. The religion is the Roman Catholic, and the bishoprics are those of Bruges, Antwerp, Ghent, &c.; in all nine, under the archbishopric, or metropolitan see of Mechlin. Religious pageantry dazzles the unlettered devotee. The universities of Tournay, Douay, and St. Omer, have long been famous. The chief cities and towns are, Brussels, containing 80,000, Ghent 60,000, Antwerp 50,000, Mons 25,000, Bruges 20,000, Namur 20,000, Luxembourg 12,000, Roermond 10,000, and Limbourg, 8,000 inhabitants; Sluys, and Ostend. Brussels is celebrated for its manufacture of lace; Ghent for its Venetian site, being built on a number of little islands; Antwerp as the chief mart of Flemish commerce; and Cambray is renowned for its cambrics.

The climate is more remarkable for moisture than for warmth; but agriculture flourishes well, and the Netherlands yield not to Lombardy, or England, in the essentials of good husbandry. The chief rivers are, the Rhine; the Meuse, or Maes; the Scheldt; the Dyle, and the Nethe. The forest of Soigne is in Brabant; and the remains of the ancient forest of Ardennes pervade Hainault and Luxembourg, from Valenciennes to Treves.

France.—This country, 600 miles in length from north to south, and 560 in breadth from east to west, was formerly divided into provinces; but, since the revolution, it has been divided into departments. The following table contains both divisions.

Province.	*Department.*	*City.*	*River.*
Flandre Françoise	Nord	Lille	Deule
Artois	Pas du Calais	Arras	Scarpe
Picardie	Somme	Amiens	Somme
Normandie	Bas Seine	Rouen	Seine
	Calvados	Caen	Orne
	Manche	Coutances	
	Orne	Alençon	Sarte
	Eure	Evreux	Iton
Isle de France	Seine	Paris	Seine
	Seine & Oise	Versailles	Seine
	Oise	Beauvais	Therain
	Aisne	Laon	
	Seine & Marne	Melun	Seine
Champagne	Marne	Châlons-sur-Marne	Marne
	Ardennes	Mézières	Meuse
	Aube	Troyes	Seine
	Haute Marne	Chaumont	Marne
Lorraine	Meuse	Bar-le-Duc	Ornain
	Moselle	Mentz	Moselle
	Meurthe	Nancy	Meurthe
	Vosges	Epinal	Moselle
Province.	*Department.*	*City.*	*River.*
Alsace	Haut Rhin	Colmar	Fetcht & Lauch
	Bas Rhin	Strasburg	Rhine
Bretagne	Ille & Vilaine	Rennes	Vilaine
	Côtes du Nord	St. Brieux	Near the Sea
	Finisterre	Quimper	Oder
	Morbihan	Vannes	Sea-port
	Loire Infre	Nantes	Loire
Maine et Perche	Sarthe	Le Mans	Sarte
	Mayenne	Laval	Mayenne
Anjou	Mayenne and Loire	Angers	Mayenne
Touraine	Indre & Loire	Tours	Loire
Orleannois	Loiret	Orleans	Loire
	Eure & Loire	Chartres	Eure
	Loire & Cher	Blois	Loire
Berri	Indre	Châteauroux	Indre
	Cher	Bourges	Eure
Nivernois	Nievre	Nevers	Loire
Bourgogne	Yonne	Auxerre	Yonne
	Côte d'Or	Dijon	Ouche
	Saône & Loire	Mâçon	Saône
	Ain	Bourg	Ressouze
Franche Comté	Haute Saône	Vesoul	
	Doubs	Besançon	Doubs
	Jura	Lons-le-Saunier	Valliere
Poitou	Vendée	Fontenay-le-peuple	Vendée
	Deux Sèvres	Niort	Sèvres
	Vienne	Poitiers	Clain
Marche	Haute Vienne comprising part of Limosin	Limoge	Vienne
	Creuse	Guèret	Creuze
Limosin	Corrèze, comprising part of Haute Vienne	Tulle	Corrèze
Bourbonnois	Allier	Moulins	Allier
Saintonge, comprising Aunis	Charente Inférieure	Saintes	Charante
Angoumois comprising part of Saintonge	Charente	Angouleme	Charante
Auvergne	Puy de Dôme	Clermont	
	Cantel	St. Flour	
Lyonnois, Forêt & Beaujolcis	Rhône	Lyon	Rhône
	Loire	Montbrison	
	Isère	Grenoble	Isère
Dauphinè	Hautes Alps	Gap	Rhône
	Drôme	Valence	
Gyenne, comprehending Gascogne	Dordogue	Perigueux	Ille
	Gironde	Bordeaux	Gironde
	Lot & Garonne	Agen	Garonne
	Lot	Cahors	Lot
	Aveyron	Rhodez	Aveyron
	Gers	Auch	Gers
	Landes	Mont-de-Marsan	Douze
	Hautes Pyrénées	Tarbe	Adour
Bearne	Basses Pyrénées	Pau	Le Cave de Pau
Comté de Foix	Arriege	Tarasçon	Arriege
Roussillon	Pyrénées Orientals	Perpignan	Tot
Languedoc	HauteGaronne	Toulouse	Garonne
	Aude	Carcassonne	Aude
	Tarne	Castres	Agout
	Garde	Nimes	Vistre
	Lozere	Mende	Lot
	Ardéche	Privas	Near the Rhône
	Haute Loire	Le Puy	Borne
	Héraut	Montpellier	

Province.	*Department.*	*City.*	*River.*
Provence	Bouches du Rhone	Aix	Arc
	Basses Alps	Digne	
	Var	Toulon	Mediter. Sea
Corsica	Golo	Bastia	
	Liamone	Ajaccio et Bastia	

The conquests made by France during the late wars, from 1792 to 1814, are not integral parts of her dominions; as most of them have been given up to their parent states.

The islands belonging to France, are the isles of Hieres, near Toulon, which are the same as Homer's isle of Calypso, in the Mediterranean; the isles of Rhe, Belleisle, and Oleron, near Rochelle, are in the bay of Biscay. Corsica is the birthplace of Napoleon Buonaparte.

The established religion in France is the Roman Catholic; but the Gallican Church is more independent of the See of Rome than that of any other country professing the same faith. Before the revolution, there were in France 17 archbishops, 750 great convents of monks, and 200 nunneries: the monks and nuns were reckoned 200,000, and the revenues of the clergy and religious houses six millions sterling.

The government is an hereditary monarchy, confined to the male branches of the house of Bourbon, in the succession of Charles X.; then the Duke of Angouleme; the Duke of Bourdeaux, son of the Duke de Berri; the Duke of Orleans, and his sons; Prince of Condé, &c.

The population is estimated at 31 millions; and the army at 250,000 men; the navy is inconsiderable; the revenue is about 25 millions sterling. The French in their manners possess a singular degree of vivacity and gaiety, and frivolity of disposition; and their politeness is the result of affectation and pride, rather than of physical purity and tutored elegance.

In some branches of experimental philosophy the French have made considerable progress, but in regard to mechanics, and the application of machinery in abridging labour, they have always been the pupils of the British. The universities of France were formerly those of Douay, Cäen, Paris, Rheims, Nanci, Strasbourg, in the north; Nantes, Angers, Poitiers, Orleans, Bourges, Dijon, Besançon, in the middle; and Bourdeaux, Pau, Perpignan, Toulouse, Montpellier, Aix, Orange, and Valence, in the south.

The chief cities are, Paris, the capital, with a population of 600,000 inhabitants; Lyons, 100,000, and famous for its manufactures of articles of luxury; Marseilles and Bourdeaux, each peopled with about 80,000 inhabitants; Lisle, noted for its fortifications, boasts a population of 60,000 inhabitants; Amiens, 40,000; Rouen, the capital of Normandy, 72,000; Brest, the chief maritime arsenal, 30,000; Nantes, 56,000; Orleans, 40,000; Strasbourg, 40,000; and Thoulouse, 50,000 souls.

The inland navigation of France is confined to the canal of Briare, or Burgundy; the canal of Orleans; the canal of Picardy; and that of Languedoc, planned and executed by the engineer Riquet, during the ministry of Colbert, in the reign of Louis XIV.

In regard to its climate, France may be divided into three regions: the bleak air of the north; the salubrious atmosphere of the middle region; and the genial south, so inviting to invalids from Britain. The north, west, and interior of France, are diversified with rivers, canals, forests, and mountains; but in general the plain predominates. Cornwall finds its rival in the gravelly heaths of Britany; from Flanders to Orleans a rich loam prevails, like what we meet with in Middlesex, and the adjacent counties: the mountainous region of the south is fertile; and the common products are corn, grapes, fruits, olives, tobacco, hemp, flax, silk, manna, and saffron.

The chief rivers are the Seine, the Loire, the Rhone, the Garonne; and the lakes are those of Provence, among the Vosges of Alsace, and some other provinces. The mountains are those of Britany, the Vosges, Mount Jura, the Alpine ridges of Dauphiné; the Cevennes, about 6000 feet high; and the Pyrénées. The forests are Orleans, Ardennes, the former the retreat of banditti, the latter renowned for deeds of chivalry; and the forest of Fontainebleau. The desert of La Crau, comprising a plain of 150,000 acres, of Provence, is entirely composed of round gravel, or shingle, than which the sea shore is not more barren.

Spain.—Spain, from west to east is about 600 miles long, and from north to south the breadth is reckoned 500 miles; and situated between the 36th and 44th degrees of north latitude; the climate is delightful and the soil luxuriant.

The population is estimated at 11 millions; the army at 60,000; and the revenue at five millions and a half sterling. The government is absolute and hereditary monarchy. Spain is at present divided into 22 provinces for the crown of Castile, and four for Arragon. Those for Castile are, the kingdom of Gallicia, the provinces of Burgos, Leon, Zamora, Salamanca, Estremadura, Valencia, Valladolid, Segovia, Avila, Toro, Toledo, La Mancha, Murcia, Guadalaxara, Cuença, Soria, Madrid, and Andalusia. The four for Arragon were formerly the Moorish kingdoms of Seville, Cordova, Jaen, and Grenada. The most common and generally received division of Spain is as follows:

Kingdoms.	*Capitals.*
The kingdom of Gallicia, ...	St. Jago di Compostella.
The principality of Asturias,	Oviedo.
The lordship of Biscay,......	Bilboa.
The kingdom of Navarre, ...	Pampeluna.
The kingdom of Leon, ...	Leon.
The kingdom of Old Castile,..	Burgos.
The kingdom of Arragon, ...	Saragossa.
The principality of Catalonia,	Barcelona.
The province of Estremadura,	Badajos.
The kingdom of New Castile,	Madrid.
The kingdom of Valencia,....	Valencia.
The kingdom of Andalusia, ..	Seville.
The kingdom of Murcia, ...	Murcia.
The kingdom of Grenada,...	Grenada.

The Islands of		
Majorca,......	The Ancient Baleares	Majorca.
Ivica, ...		Ivica.
Minorca,......		Port Mahon.

The chief rivers are the Ebro, the Douro, the Tagus, the Guadiana, and the Guadalquiver; the Bidasoa and the Tinto. And among the lofty mountains of this country we may enumerate the Pyrenees, the Cantabrian mountains, the Mountain of the Sierra Molina, the Sierra Morena, the Sierra Nevada, Montserrat, and Gibraltar. The Ebro falls into the Mediterranean, the Douro into the Atlantic at Oporto, the Tagus into the Atlantic at Lisbon, the Guadiana into the Bay of Cadiz, the Guadalquiver into the Atlantic at St. Lucar, the Bidasoa separates France and Spain, and the Tinto, or Yellow Stream, empties itself into the Mediterranean at Huelva. The Pyrenees separate France from Spain; the Cantabrian mountains extend from Roncevalles to Cape Finisterre; the Molina separate Old from New Castile; the Morena divides Castile and Estremadura from Andalusia; the Nevada, or Snow Mountains, run east and west through Grenada; Montserrat is 3300 feet high, and 30 miles from Barcelona; and Gibraltar, the Calpe of the ancients, is the key to the Mediterranean, held by Great Britain.

The chief cities and towns in the kingdom of Gallicia are, St. Jago, Corunna, Ferrol, Moldonedo, Lugo, Ortense, and Tuy. In Asturias are Oviedo, Santillana, Aviles, and St. Vincent. In Biscay are Bilboa, Tolosa, Vittoria, and Malaga. In Andalusia are Seville, Cordova, Cadiz, and Xeres. In Old Castile are Burgos and Valladolid. In Navarre are Pampeluna, Olita, Tudela, Estella, and Sangues. Saragossa, Terracona, Huesca, Bulbastro, Teruel, Ainsa, and Jaen, are in Arragon. Catalonia is celebrated for the most industrious inhabitants of Spain, and their chief towns are, Barcelona, Montenello, Tarragona, and Roses, anciently called Rhodope. In Valencia are, Valencia, Monviedro, Gandia, and Alicant. Murcia and Castigna are in the kingdom of Murcia. In Grenada are, Grenada, Soria, Segovia, Madrid, and Toledo. In Leon are, Leon, Salamanca, Zamora, and Ciudad Rodrigo. In Estremadura are, Merida, Badajos, and Placentia.

Though the climate be generally healthy, the *solano*, a noxious wind, which blows from the south-east, produces a sensation bordering on madness; but its duration seldom exceeds three days. And, except in the two Castiles, the soil so peculiarly fertile, abounds in excellent pastures, vineyards, groves of orange and lemon trees. The horses have long been celebrated for their Arabian beauty and fleetness; and the sheep called *Merinos* yield the government an annual profit of £1,666,666 sterling. Wolves, bears, and locusts, are common in Spain; it is celebrated also for its hares, partridges, pheasants, and game of various kinds.

The Spaniards are proud and cold upon a first introduction to strangers, but possess, on acquaintance, both urbanity and vivacity under this repulsive exterior. Their sobriety and temperance are proverbial; and the grandees and nobles live, in general, in a state of much simplicity, without parade or ostentation; but upon particular occasions they display a splendour and magnificence not to be equalled by the nobility of any other kingdom. They are fond of theatrical amusements, bull fights, and dancing.

The religion is the Roman Catholic, and the inquisition has reigned with exorbitant power. The archbishops are eight, the bishoprics are forty-six; and the clergy and religious persons are computed at 188,625! exempt from the usual avocations of life. The Spanish people had embraced a free constitution, and re-established their parliament or *Cortes;* but their ungrateful monarch, by the help of French bayonets, has remounted an absolute throne, and ecclesiastical domination has, at the same time, resumed its tyranny over the public mind.

Portugal.—Portugal, the most westernly country of Europe, is about 360 miles long, and 120 broad; and the population is about two millions and a half. The religion is Roman Catholic, the government absolute and hereditary monarchy; but the royal family have emigrated to Brazil, and Portugal now is governed by a viceroy! Portugal is divided into six provinces, *viz.*—1. Entre Douro e Minho. 2. Tra los Montes. 3. Beira. 4. Estremadura. 5. Alentejo. 6. Algarva.

The chief colonies are Brazil, Madeira, and some settlements on the coast of Africa, with Goa and Macao in the East Indies.

The army is computed at 24,000 men; the naval power thirteen sail of the line, and fifteen frigates; and the revenue two millions sterling. The Portuguese are, in general, an elegant people; the peasantry are miserable vassals of the nobility, whose prejudices are pernicious and impolitic.

The chief cities and towns are, Lisbon, the capital, with a population of 200,000 inhabitants; Oporto, 30,000; Braga, Coimbra, Ivora, and Tavora. The climate is excellently salubrious, and the country is generally fertile, abounding in vineyards, groves of orange and lemon trees, but agriculture is little cultivated.

The chief rivers are the Tagus, the Mondega, the Toro, and the Cadaon. And the mountains are those of Idubeda, passing the town of Guarda; the chain of Arrabeda, in Estremadura; and the chain of Alentejo, running between the city of Ivora and the town of Estramas; and Cintra, near Lisbon. The Portuguese islands are, the Azores, comprising the isles of St. Michael Tercera, Pico, or the Peak, Fayal, Florez, and Corvo. In general, these islands are mountainous, and exposed to earthquakes and violent storms, yet their produce of wheat, wine, fruits, and wood, is very abundant.

Switzerland.—This country is bounded on the east by the Tyrol and Austrian Suabia, on the west by France, on the north by the Black Forest, and on the south by Savoy and Italy. Its length, from east to west, is 200 miles, and its breadth about 130 from north to south. Switzerland is the most mountainous country in Europe, but the air is salubrious, the soil fertile, and its wildest regions are diversified by cultivated fields and vineyards, extensive lakes and verdant vales, umbrageous woods and frightful glaciers.

The Thirteen original Cantons are:

The Cantons of	*Towns.*	*Lakes.*	*Rivers.*
1. Zurich, ...	Zurich, ...	Zurich.	
2. Berne, ...	Berne, ...	....	Aar.
3. Basil, ...	Basil, ...	....	Rhine.
4. Underwalden, ..	Stanz and Sarne.		
5. Schweitz, ...	Schweitz.		
6. Zug, ...	Zug, ...	Zug.	
7. Glaris, ...	Glaris.		
8. Soleure, ...	Soleure, ...	....	Aar.
9. Uri, ...	Altorf, ...	. ..	Reuss.
10. Appenzell, ...	Appenzell.		
11. Lucerne, ...	Lucerne, ...	Lucerne.	
12. Fribourg, ...	Fribourg, ...	....	Sanen.
13. Schaffhausen . .	Schaffhausen, ...	....	Rhine.

In 1803, the following cantons were added by the French to Switzerland:—Argovia, Thuringia, Tessin, Grisons, St. Gall, and Vaud.

The religion of Switzerland is mixed; some cantons professing Catholicism, while others are Calvinistic Protestants. The Catholic cantons are, Uri, Schweitz, Underwalden, Zug, Lucerne, Fribourg, Soleure, Berne. The Protestant are, Zurich, Basil, Schaffhausen, Part of Glaris, and Appenzell.

The government is a strange mixture of aristocracy, venal oligarchy, and bold democracy; and under these respective forms, we find laws sufficiently jealous and severe; but the people are renowned for their morality and frank independence. The population amounts to two millions of souls; the military force is reckoned at 20,000 men; and the revenue about a million sterling. But taxation must be moderate where the people are proverbially poor; and foreign subsidies, arising from the permission of the youth to serve as mercenaries in the armies of other countries, swell the resources to equal the expenditure.

The city of Basil contains 14,000 inhabitants, and is celebrated for its university; Berne 13,000, and its college; Zurich, for its college and public library; Lausanne, 9000 inhabitants; Fribourg and Schaffhausen each 6000, and Lucerne 5000.

The chief rivers are the Rhine and the Rhone, the Aar and the Reuss, the Lien and the Fleur; and the lakes are both numerous and picturesque. Constance, Geneva, Maggiore, Lugano, Neufchatel, Zurich, and Lucerne, are the chief lakes. The mountains are, the Alps, covered with snow at their summits; Mount Rosa, Mount Blanc, Mount St. Bernard, and Mount St. Gothard.

The horses of Switzerland are esteemed for their vigour and spirit; and the ibex (a species of goat) is as common among the Alps as are goats in Wales. In the day he ascends the highest summits, but at night he seeks the valleys to browze on aromatic plants. When scared, the ibex will dart up a perpendicular rock of eighteen feet high, at three springs; bounding like a racket-ball struck against a stone wall. The chamois and the marmot are common; and in the highest Alps the bearded vulture preys upon the white hare, the marmot, the chamois, kids, and lambs.

Italy.—This country is usually divided into three parts, the northern, middle, and southern. It is a beautiful and fertile peninsula, assuming the appearance of a boot-leg on the map, and admirably adapted for commerce. Its length is 670, and its medial breadth 100 miles. The population is thirteen millions; of which, allowing six millions for Naples and Sicily, and three millions for the Pope's dominions, there will be four millions for the northern states.

In the north the Alpine scenery is truly sublime; the Apennines give many charms to the central part; Florence and Tivoli excite the traveller's admiration; and Naples is generally beautiful, though exposed to the fiery irruptions of Vesuvius.

The chief rivers are the Po, the Adige, the Brenta, the Piara, the Arno, and the Tiber, with the Rubicon, or Fiumessino, a diminutive stream which falls into the Adriatic. The lakes are those of Maggiore, Lucamo, Lugano, Como, Lecco, Iseo, Di Garda, in the north; Perugia, Bolsena, Rieti, Albano, and Nemi, in the central part; and Celano, and Varano, in the Neapolitan territory. The mountains are the Alps, the Apennines, and Vesuvius.

Naples and Sicily forming the southern part, may be regarded as one kingdom. Sicily, separated from Naples by the strait of Messina, is an island about 170 miles long and 80 broad. Next to Constantinople, Naples is the most charming city, for situation, in Europe.

The Strait of Messina is celebrated for the Scylla and Charybdis of the ancients; the former being a lofty rock on the

Calabrian shore, and the latter a spot where the waves, greatly agitated by numerous pointed rocks at the bottom of the sea, assume the appearance of a whirlpool.

The Lipari isles, adjacent to Sicily, are celebrated for their rocks of volcanic glass, and the grotto of the sea ox—a cavern 60 feet high, 200 feet long, and 120 feet broad, situated in Felicuda. Malta and Gogo are valuable in a maritime point of view.

The central part of Italy, comprising the dominions of the Church, Tuscany, Lucca, St. Marino, Piombino, and the isle of Elba, may be thus illustrated:—The dominions of the Church yield £350,000 sterling annually; the revenue of the Grand Duchy of Tuscany is half a million yearly; the Luccanese are the most industrious people of Italy; the diminutive republic of St. Marino claims the Pope's protection; the principality of Piombino, on the Italian shore, and opposite to the isle of Elba, is a neglected spot, and both are known best for their iron ores.

Piedmont, Milan, Mantua, Parma, and Placentia, Modena, and Genoa, in the north of Italy, now claim our attention.

Piedmont, with Savoy, is 150 miles long and 100 broad, and belongs to the King of Sardinia.

The capital of Piedmont is Turin, containing 80,000 inhabitants; Vercelli, 20,000; Alexandria, 12,000; a little to the east of which is Marengo.

The fertile duchy of Milan contains 2432 square miles, and a population of more than a million of inhabitants.

Milan, the chief city, contains 120,000 inhabitants; Pavia is celebrated for its university, as is also Padua; and Verona is not more renowned for its antiquities, than Venice for its enchanting maritime situation, and the wealth of its merchants.

The small duchy of Mantua contains but 12,000 inhabitants; while that of Modena boasts a population of 320,000, and a revenue of £140,000.

The population of Parma and Placentia is reckoned 300,000; the revenue £175,000; the soil is rich, the pastures fine, and the Parmesan cheese has been celebrated for centuries.

Genoa assumed the title of the Liburian Republic shortly after 1798; but it now belongs to Sardinia. The population is computed at 400,000; the city, 80,000; and the troops, 30,000.

Lombardy, Mantua, the ancient Republic of Venice, and Dalmatia, belong now to Austria; the grand duchy of Tuscany to the Archduke Ferdinand; and Parma and Placentia to the ex-empress Maria Louisa.

Turkey in Europe.—The Turkish dominions contain 182,560 square miles, comprising many ancient kingdoms and republics, whose classic names but tell the fleeting grandeur of remote antiquity.

The following are the names, both ancient and modern, of the provinces of the Turkish empire:

	Modern.	*Ancient.*
1.	Moldavia, *north*, ...	Dacia.
2	Budzac, or Bessarabia, ..	Getæ and Peucini.
3.	Walachia, ...	Dacia.
4.	Bulgaria, ...	Mœsia.
5.	Romelia, ...	Thracia, Pæonia, Macedonia, Græcia.
6.	The Morea, ...	Peloponnesus.
7.	Albania, ...	Epirus, Chaonia, and Part of Illyricum.
8.	Dalmatia, ...	Dalmatia.
9.	Servia, ...	Pannonia.
10.	Bosnia, ...	
11.	Turkish Croatia, ...	Pannonia and Noricum.

Turkey extends 870 miles from north to south, and 680 in breadth from east to west; and its population may be estimated at eight millions The established religion is the Mahommedan; but about two-thirds of the people are Greek Christians, who, along with their religion, retain their priests, bishops, archbishops, and patriarchs. In the Mahommedan faith there are also the mufti, or pontiff, who presides at Constantinople; the moublahs, or doctors of the law, the Koran being a code of civil and religious observance; the inferior muftis, or judges, and the cadilesquiers, or chief justices; the imaums, or parish priests, who perform the service of the mosques; the dervishes, or monks, of whom there are four various orders, or institutions.

The government is despotic, but the sultan's power, subject to the laws of the Koran, is wisely balanced by a religious aristocracy. The Turkish navy amounts to thirty ships of the line; and the army to 150,000 ill-disciplined and mutinous troops. The revenue is computed at seven millions sterling, partly derived from a capitation tax on unbelievers, and partly from a land tax and the customs.

The Turks are abstemious in diet; their chief furniture is the carpet which covers the floor; their amusements partake of indolent apathy; but the personal cleanliness of both sexes is highly laudable.

The chief cities and towns are, Constantinople, with a population of 400,000 souls; of whom 200,000 are Turks, 100,000 Greeks, and the remainder Armenians, Jews, and Franks. Adrianople, 140 miles north-west of Constantinople. Filipopoli, a mean town, whose situation is so low, that the mud in its streets is sometimes knee deep, and the foot passengers get along only by stones, erected like posts, to facilitate the intercourse of a wretched city considerable in size. Sosia has 70,000 inhabitants; Silistria, in Bulgaria, 60,000; Bucharest, in Walachia, 60,000; Jaffy, in Moldavia, and Bender, in Bessarabia, each 12,000; Belgrade, in Servia, 25,000; Banjaluka, in Bosnia, 18,000; Salonica, 60,000; Larissa, 25,000; while Atini (Athens) is a miserable village.

Turkey is famous for carpets, currants, figs, saffron, statuary marble, silk, and drugs.

The climate is delicious, the air pure, and the seasons regular; and though the soil be rich, agriculture is neglected; and the Turks excel in no one useful art or science.

The chief rivers are the Danube, the Maritz, or ancient Hebrus, which falls into the Ægean sea; the Esker; the Morava, anciently the Margus; and the Drin, which falls into the Save. The lakes are chiefly found in Budzac and Walachia round Ismail, and some in Albania. The mountains are those of Hæmus, Acroceraunia, Pindus, Olympus, Ossa, Pelius, and Mount Athos, resembling Mount Serrat in Spain, and celebrated for its monasteries and cells of devout hermits. The islands belonging to Turkey in Europe are, Cerigo and Candia on the south coast of the Morea; Milo, Santerim, Stanpalin, Paros, Naxia, Engia, Zia, and Zine, on the east; Andro, Negropont, and Skyros, east of Livadia. South of the island of Pâros is Antiparos, whose grotto is the admiration of travellers. The whole isle is one huge rock of fine white marble, and the grotto is distinguished from the caverns in Derbyshire, by the snowy whiteness of the calcareous spar which appears on either hand, or suspended from the roof in the most elegant and picturesque forms. The present struggle in Greece for liberty, is so very problematical, that we have kept entirely aloof from the political aspect which this once classic land now wears.

On the west of Epirus are Corfu, St. Maura, Ithaca, Cephalonia, and Zante, forming a new republic, under the protection of Great Britain.

EUTOCIUS, an eminent mathematician, who lived at the time of the decline of the sciences in Greece, was a native of Ascalon, in Palestine, and a disciple of Isodorus, one of the celebrated architects employed by the emperor Justinian. He probably flourished about the commencement of the sixth century, though we have no particulars respecting his life; but his works reflect much honour on his memory. He wrote elaborate and perspicuous "Commentaries on the Books of Archimedes concerning the Sphere and Cylinder;" and also on the first four books of the conics of "Apollonius Pergæus." These commentaries have not only elucidated many difficult passages in those profound writers, but have tended to throw light on the history of mathematics.

EVAPORATION, in Natural Philosophy, is the conversion of water into vapour, which becoming lighter than the atmosphere, is carried considerably above the earth's surface; and afterwards by a partial condensation forms clouds, and finally descends in rain. Various hypotheses have been advanced to account for the process of evaporation, some attributing it to one cause, and some to another; and it is difficult to say which has the greater claim to attention, as none of them appear perfectly satisfactory. This being the case, and as our limits will not admit of a long detail of all the theories that have been written on this subject, our remarks shall embrace the most interesting experiments, observations, and phenomena, relating to evaporation.—That water salted to about the same degree as salt-water, and exposed to a heat equal to that of a summer's day, did, from a circular surface of about eight inches' diameter, evaporate at the rate of six ounces in twenty-four hours. Whence, by calculation, the thickness of the pellicle or skin of water, evaporated in two hours, was the fifty-third part of an inch; but, for a round number, suppose it only a sixtieth part; then, if water as warm as the air in summer evaporates the thickness of one-sixtieth part of an inch in two hours, from its whole surface, in twelve hours it will evaporate the tenth of an inch: which quantity will be found abundantly sufficient to furnish all the rains, springs, dews, &c. By this experiment, every ten square inches of surface of the water yield in vapour, daily, a cubic inch of water: and each square foot, half a wine pint; every space of four feet square, a gallon; a mile square, 6914 tuns; and a square degree, of 69 English miles, will evaporate 33,000,000 tuns a day; and the whole Mediterranean, computed to contain 160 square degrees, at least 5280,000,000 of tuns each day. A surface of eight square inches, evaporated, purely by the natural warmth of the weather without wind or sun in the course of a whole year, 16,292 grains of water, or 64 cubic inches; the depth of water, therefore, evaporated in 12 months, amounts to 8 inches. But the annual evaporation is actually from 48 to 36½ inches. Water evidently evaporates more in windy than in calm weather, as the fleecy vaporous air is then more speedily dissipated. And in May, June, July, and August, the evaporation is greatest. Many experiments have been made to determine the precise rate of evaporation by different philosophers, and we learn that the evaporation is confined entirely to the surface of the water: hence it is in all cases proportional to the surface of the water exposed to the atmosphere. Much more vapour of course rises in maritime countries, or those interspersed with lakes, than in inland countries. Much more vapour rises during hot weather than during cold: hence the quantity evaporated depends in some measure upon temperature. The precise law has been happily discovered by Dalton, who says, in general, the quantity evaporated from a given surface of water per minute, at any temperature, is to the quantity evaporated from the same surface at 212°, as the force of vapour at the first temperature is to the force of vapour at 212°. Hence, in order to discover the quantity which will be lost by evaporation from water of a given temperature, we have only to ascertain the force of vapour at that temperature. Hence, we see that the presence of atmospheric air obstructs the evaporation of water; but this evaporation is overcome in proportion to the force of the vapour. The quantity of vapour which rises from water, even when the temperature is the same, varies according to circumstances. It is least of all in calm weather, greater when a breeze blows, and greatest of all with a strong wind. *See* FREEZING.

EVECTION, in Astronomy, the most considerable of the lunar irregularities, caused by the action of the sun upon the moon; the lunar evection was discovered by Ptolemy, and is the first irregularity in the motion of this body with which the ancients were acquainted. Its general and constant effect is to diminish the equation of the centre in the syzigies, and to increase it in the quadrature, and may be explained by a change supposed to take place in the eccentricity of the lunar orbit, and at the same time a motion in the apogee. This inequality can be represented very exactly, by supposing it proportional to the sine of double the angular distance of the moon from the sun, *minus* the mean anomaly of the moon, and the co-efficient to this proportion is now generally stated in modern astronomical works at 1° 20′ 28″, whence the formula for the evection is

(1° 20′ 28″) × sin. 2 dist. ☾ ☉ — mean anomaly ☽

from which it is easy to follow the successive variations of this equation, for in order to this it is only requisite to consider the different values which its argument can take. It is also very easy to find the period of evection from the variation in the value of the angle on which it depends. For this purpose it will be sufficient to calculate the variations of this angle in a given time, and thence to conclude by a simple proportion, the number of days necessary for it to vary 360°. This period differs but little from the periodic revolution of the moon; *viz.* 27·178533 days.

EVERGREEN, in Gardening, a species of perennials which continue their verdure all the year.

EVICTION, signifies a recovery of lands or tenements by law.

EVIDENCE, in Law, proof by testimony of witness on oath, or by writings, or records adduced before a court, or competent jurisdiction. It is twofold, written or verbal; the former by records, deeds, bonds, or other documents; the latter by witnesses examined *viva voce*, and called technically, parole evidence. It is also either absolute or presumptive; and may be that which is given in proof by the parties, or which the jury know of themselves, for every thing which makes a fact or thing evident to them, is called evidence.

Witnesses are summoned by writ of subpœna to attend, on penalty of £100 to the king, and £10 to the party, besides damages sustained by their non-attendance. All witnesses of all religions, who believe in a future state of rewards and punishments, are received, but not persons infamous in law by their crimes, nor persons directly interested in the matter at issue; and no counsel or attorney shall be compelled to disclose the secrets intrusted to him by his client, but he may give evidence of facts which he knew by other means than for the purpose of the cause. One witness is sufficient to any fact, except in high treason, when two are required; but that is only in treasons of conspiracy against the state, and not treason relating to the coin, &c. The oath of the witness is to speak the truth, the whole truth, and nothing but the truth; and all evidence is to be given in open court. The general rules of evidence are:—1. The best evidence must be given that the nature of the thing is capable of. 2. No person interested in the question can be a witness; but to this there are exceptions; as, first, in criminal prosecutions; secondly, for general usage, for convenience of trade, as a servant to prove the delivery of goods, though it tends to clear himself of neglect. 3. Where the witness acquires the interest by his own act, after the party who calls him has a right to his evidence. The third rule is, that hearsay of a matter of fact is no evidence; but of matter of reputation, such as a custom, it is in some sort evidence. 4. Where a general character is the matter in issue, particular facts may be received in evidence, but not where it occurs incidentally. 5. In every issue the affirmative is to be proved. 6. No evidence must be given of what is agreed, or not denied, upon the pleadings.

Of Persons competent to give Evidence.—The king cannot be a witness under his sign manual, and a peer must be sworn. A judge and juror may give evidence. Members of a corporation cannot be heard in a cause of the corporation. In actions against churchwardens, &c. for money misspent, &c. parishioners may be evidence. Kinsmen are not to be objected to. Husband and wife are not received as witnesses for or against each other; and the bail cannot be a witness for his principal, on account of his direct interest in the event. One that has any benefit under a will, or deed, must release it before he can prove it as a witness; any devise to a person who is witness to a will, or codicil, is void, and he shall be received as a witness. A bare trustee, it is said, may prove a deed made to himself. In actions for penalties on usury, the borrower, after he has paid his money, may be a witness to prove it. In actions against the hundred, a party is received as a witness in his own cause. Persons not of sound memory, attainted of præmunire or conspiracy, convicted of felony, perjury, or other infamous crimes, are incompetent to be received as witnesses; but these are restored to competency by the king's pardon; and the witness shall not be asked any question to accuse himself, but it must be proved by producing the conviction; but upon conviction of perjury, under statute 5 Eliz. c. 9, nothing but a reversal of judgment can restore a man to competency.

Wills of land must be attested and subscribed in the presence of the testator by three witnesses. In general, the courts are inclined to favour the receiving of evidence, and to consider objections as to interest, to go more to the credibility of the witness than to his competency.

When a witness is not liable to any legal objection, he is first examined by the counsel for the party on whose behalf he comes to give evidence, which is called his examination in chief, who is not to put what is called leading questions, *viz.* to form them into such a way as would instruct the witnesses in the answers he is to give. He is then cross-examined by the other side, when leading questions are necessarily put; and then he is re-examined as to what he has been asked in his cross-examination. The party examined must depose those facts only of which he has an immediate knowledge and recollection; he may refresh his memory with notes taken by himself at the time, and if he can then speak positively as to his recollection, it is sufficient; but if he have no recollection further than finding the entry in his book, the book itself must be produced. Deeds, receipts, and writings requiring stamps, must be stamped before they can be received in evidence. Parole evidence shall not be admitted to annul or substantially vary a written instrument, nor to explain the meaning of a testator in a will, though where there are two persons of the same name, and it is doubtful which is the devisee, from an imperfect description, it must be proved by witnesses which is the devisee. By the statute of frauds, several things must be evidenced by writing, which previously might be proved by parole only. The general rule has been, for the last century, under the ablest judges, that no man shall be asked a question, the answer to which might subject him to criminal punishment or pecuniary penalty. It has been lately attempted by some judges to extend it further, to prevent any question being asked which may degrade a man's character, which it is feared will deprive the parties of all the substantial benefits of cross-examination.

EVOLUTION, in War, the motion made by a body of troops, when obliged to change their form and disposition, to preserve a post, or occupy another, to attack an enemy with more advantage, or to be in a better condition of defending themselves.

EVOLUTION, in Arithmetic and Algebra, is the extraction of roots; being thus opposed to involution, which is the rising of powers.

EXCENTRICITY OF THE ORBIT OF A PLANET, in Astronomy, is the distance between the centre and the focus of the ellipse in which it revolves. The discovery of the excentricity in the orbits of the sun and moon is attributed to Hipparchus, who wrote a treatise on this subject 150 years before our era. The eccentricity of the orbit is computed from the greatest equation of the centre, by the following proposition: As $57^\circ\ 17'\ 44''.8$, (the arc $=$ rad.) is to half the greatest equation, so is rad. $= 1$ to the excentricity. *See* ASTRONOMY and EQUATION.

EXCEPTION, in Law, is a stop or stay to any action. In law proceedings, it is a denial of matter alleged in bar to an action; and in chancery, it is what is alleged against the sufficiency of an answer.

EXCESS, in Arithmetic and Geometry, is the difference between any two unequal numbers or quantities.

EXCHANGE, in Arithmetic, is the reduction of different coins or any denominations of money, whether there be real coins answering to them or not, from one to another: or the method of finding how many of one species, or denomination, are equal in value to a given number of another; in order to which it is necessary to know the value of the coins and moneys of account of different countries, and their proportion to each other according to the settled rate of exchange. The several operations in this case are only different applications of the rule of three. The par of exchange is always fixed and certain, it being the intrinsic value of foreign money, compared with sterling; but the course of exchange rises and falls upon various occasions. Thus in some parts of France, they keep their accounts as at Paris, Lyons, and Rouen, in livres, sols, and deniers, and exchange by the crown, $=$ 4*s.* 6*d.* at par; and to change French into sterling, we say, As one crown is to the given rate, so is the French sum to the sterling required; or thus, to change sterling into French, As the rate of exchange is to one crown, so is the sterling sum to the French required. To illustrate which, take these examples:

1. How many crowns must be paid at Paris, to receive in London £180 exchange at 4*s.* 6*d.* per crown?

d. *cr.* £.
As 54 : 1 : : 180 :
240

54) 43200 800 *cr.*
432

....

2. A merchant at Paris remits to his correspondent in London 600 crowns, at 4*s.* 6*d.* each, which is the value in sterling?

cr. *d.* *cr.*
As 1 : 54 : : 800 :
54

12) 43200

2|0) 360|0

£. 180

And these examples will suffice for other places; for where the rate of exchange is known, we can easily determine how much must be paid or received in any transaction with a foreign country.

Arbitration, or *Comparison* of EXCHANGE, determines the method of remitting to, or drawing upon, foreign places, in such a manner as shall be most advantageous to the merchant, and is either simple or compound.

Simple Arbitration, respects three places only. Here, by comparing the par of arbitration between a first and second place, and between the first and a third, the rate between the second and third is discovered; from whence a person can judge how to remit or draw to the most advantage, and to determine what that advantage is.

Compound Arbitration, respects the cases in which the exchanges among three, four, or more places are concerned. A person who knows at what rate he can draw or remit directly, and also has advice of the course of exchange in foreign parts, may trace out a path for circulating his money, through more or fewer of such places, and also in such order, as to make a benefit of his skill and credit; and in this lies the great art of such negociations.

EXCHANGE, in Law, is a mutual grant of equal interests, the one in consideration of the other. In exchange, the estates of both parties should be equal; that is, if the one has a fee-simple in the one land, the other should have a like estate in the other land; and if the one has fee-tail in the one land, the other ought to have the like estate in the other land: and so of other estates.

EXCHEQUER, an ancient court of record, established by William the Conqueror, and intended principally to order the revenues of the crown, and to recover the king's debts and duties. The court consists of two divisions, *viz.* the receipt of the exchequer, which manages the royal revenue; and the judicial, which is subdivided into a court of equity, and a court of common law.

EXCHEQUER *Bills*, bills or tickets issued by the Exchequer, payable out of the produce of a particular tax, or generally out of the supplies granted for the year, and receivable in all payments to the exchequer. The interest payable on them has been at various rates according to the current rate of interest at the time they were issued; those at present (1824) in circulation, bear interest at the rate of 2*d.* a day per cent. They are frequently made out for £100 each, but those issued of late years have been chiefly for £1000 each, and they have sometimes been made for much larger sums; they are numbered arithmetically, and registered accordingly, for the purpose of paying them off in regular course, the time of which is notified by public advertisement. The daily transactions between the bank and the exchequer are chiefly carried on by these bills, which are deposited by the bank in the exchequer to the amount of the sums received by them on account of government; the bank notes and cash thus received by the bank being retained by them, as the detail part of the money-concerns of government is all transacted at the bank. The instalments on loans are paid into the receipt of the exchequer in exchequer bills, which are received again by the bank as cash, either for the amount of dividends due, or in repayment of advances. When these bills sell at a considerable discount, or any other circumstance indicates that the quantity of them in circulation is too great, the usual expedient is to fund a part of them, that is, to convert them into a permanent debt, by offering the holders of them stock in lieu of their bills.

EXCISE **Duties**, inland taxes on commodities of general consumption, but in general, the articles subjected to it have been such as are not absolutely essential to subsistence. Salt appears to have been the object of an excise duty at a very early period; in later times, oil, wine, tobacco, and various other consumable articles, have been burdened with duties of this description.

Excise, one of the principal branches of the public revenue, consisting of inland duties, or taxes on articles manufactured or consumed, whereas the duties of customs are paid on goods brought into or carried out of the country.

Excise, in Law, is an inland imposition, sometimes paid upon the consumption of the commodity, or frequently upon the retail sale, which is the last stage previous to the consumption. For more easily levying the revenue of the excise, the kingdom of England and Wales is divided into about fifty collections, some of which are called by the names of particular counties, others by the names of great towns; where one county is divided into several collections, or where a collection comprehends the contiguous parts of several counties, every such collection is subdivided into several districts, within which there is a supervisor; and each district is again subdivided into out-rides and foot-walks, within each of which there is a gauger or surveying officer. The officers of excise are to be appointed, and may be dismissed, replaced, or altered, by the commissioners, under their hands and seals; their salaries are allowed and established by the Treasury. If it be proved by two witnesses, that any officer has demanded or taken any money, or other reward whatever, except of the king, such offender shall forfeit his office. By several statutes, no process can be sued out against any officer of excise, for any act done in the execution of his office, until one month after notice given, specifying the cause of action, and the name and abode of the person who is to begin, and the attorney who is to conduct the action; and within one month after such notice, the officer may tender amends, and plead such tender in bar; and having tendered insufficient or no amends, he may, with leave of the court, before issue joined, pay money into court. Officers of excise are empowered to search at all times of the day, enter warehouses, or places for tea, coffee, &c. But private houses can only be searched upon oath of the suspicion, before a commissioner or justice of the peace, who can, by their warrant, authorize a search. The office of excise has also several excellent regulations for procuring the due attention and good conduct of their officers.

EXCLUSION, in Mathematics, is a method of coming at the solution of numerical problems, by previously throwing out such numbers as are of no use in solving the question.

EXCOECARIA, a genus of the triandria order, in the diœcia class of plants; and in the natural method ranking under the 38th order, tricoccæ. There are two species. The agallocha, or aloes wood, is a native of China and some of the India islands, and is about the same height and form as the olive tree. Its trunk is of three colours, and contains as many sorts of wood: the heart is that of tambac, or calombac, which is dearer in the Indies than gold.

EXCOMMUNICATION, an ecclesiastical penalty or censure, whereby such persons as are guilty of any notorious crime or offence, are separated from the communion of the church, and deprived of all spiritual advantages.

EXCORIATION, in Medicine and Surgery, the galling or rubbing off the cuticle, or external skin.

EXCRETION, or **Secretion**, in Medicine, a separation of some fluid, mixed with the blood, by means of the glands.

EXECUTION, in Law, is a judicial writ, grounded on the judgment of the court whence it issues; and is supposed to be granted by the court, at the request of the party at whose suit it is issued, to give him satisfaction on the judgment which he hath obtained; and therefore an execution cannot be sued out in one court, upon a judgment obtained in another. These are of different sorts, according to the nature of the action: In actions were money is recovered, as a debt or damages, they are of five sorts; 1. against the body of the defendant; 2. or against his goods or chattels; 3. against his goods and the profits of his lands; 4. against the goods and the possession of his lands; 5. against all three, his body, lands, and goods.

Execution *of Criminals*, must be according to the judgment; and the king cannot alter a judgment from hanging to beheading, because no execution can be warranted, unless it be pursuant to the judgment. This being the completion of human punishment, in all cases, as well capital as otherwise, must be performed by the legal officer, the sheriff or his deputy. Murderers are to be executed the day next but one after conviction, unless it be Sunday, and anatomized; for which reason they are generally tried on a Friday.

EXECUTOR, a person appointed by the testator to carry into execution his will and testament after his decease. The regular mode of appointing an executor is, by naming him expressly in the will; but any words indicating an intention of the testator to appoint an executor, will be deemed a sufficient appointment.

EXEGESIS, a discourse by way of explanation, or comment, upon any subject.

EXEMPLIFICATION of **Letters Patent**, a transcript or duplicate of them, made from the enrolment thereof, and sealed with the great seal.

EXERCISE, the preparatory practice of managing the artillery and small arms, in order to make the ship's crew perfectly skilled therein, so as to direct its execution successfully in the time of battle. The exercise of the great guns of our navy has been as well as all others, very complicated, and abounding with superfluities, but the following concise method has been introduced by an officer of distinguished abilities, with much success. As these instructions abound with several technical terms, the reader, whenever at a loss, may look for any of those articles, which are all explained in this work.

Exercise of the Great Guns.

1st. Silence.
2d. Cast loose your guns.
3d. Level your guns.
4th. Take out your tompions.
5th. Run out your guns.
6th. Prime.
7th. Point your guns.
8th. Fire.
9th. Sponge your guns.
10th. Load with cartridge.
11th. Shot your guns.
12th. Put in your tompions.
13th. House your guns.
14th. Secure your guns.

Upon beating to arms (every person having immediately repaired to his quarters) the midshipman, commanding a number of guns, is to see that they are not without every necessary article, as (at every gun) a sponge, powder-horn, with its priming-wires, and a sufficient quantity of powder, shot, crow, handspike, bed, quoin, train-tackle, &c. sending, without delay, for a supply of any thing that may be missing; and for the greater certainty of not overlooking any deficiency, he is to give strict orders to every captain under him to make the like examination at his respective gun, and to take care that every requisite is in a serviceable condition, which he is to report accordingly. And besides the other advantages of this regulation, for the still more certain and speedy account of being taken upon these occasions, the midshipman is to give each man his charge at quarters, (as expressed in the form of the monthly report,) who is to search for his particular implements, and not finding them, is immediately to acquaint his captain, that upon his report to the midshipman they may be replaced.

The man who takes care of the powder is to place himself on the opposite side of the deck from that where we engage, except when fighting both sides at once, when he is to be amidships. He is not to suffer any other man to take a cartridge from him, but he who is appointed to serve the gun with that article, either in time of a real engagement or at an exercise.

Lanterns are not to be brought to quarters in the night, until the midshipman gives his orders for so doing to the person he charges with that article. Every thing being in its place, and not the least lumber in the way of the guns, the exercise begins with—

1st. *Silence.* At this word every one is to observe a silent attention to the officers.

2d. *Cast loose your Guns.* The muzzle-lashing is to be taken off from the guns, and (being coiled up in a small compass) is to be made fast to the eye-bolt above the ports. The lashing-tackles at the same time to be cast on, and the middle of the breechings seized to the thimble of the pomilion. The sponge to be taken down, and with the crow, handspike, &c. laid upon the deck by the gun. When prepared for engaging an enemy, the seizing within the clinch of the breeching is to be cut, that the gun may come sufficiently within board for loading, and that the force of the recoil may be more spent before it acts upon the breeching.

3d. *Level your Guns.* The breech of your metal is to be seized so as to admit the foot of the bed's being placed upon the axle-tree of the carriage with the quoin upon the bed, both the ends being even one with the other. When levelled for firing, the bed is to be lashed to the bolt which supports the inner end of it, that it may not be thrown out of its place by the violence of the gun's motion when hot with frequent discharges.

4th. *Take out your Tompions.* The tompion is to be taken out of the gun's mouth, and left hanging by its laniard.

5th. *Run out your Guns.* With the tackles hooked to the upper bolts of the carriage, the gun is to be bowsed out as close as possible, without the assistance of crows or handspikes, taking care at the same time to keep the breeching clear of the trucks, by hauling it through the rings; it is then to be bent so as to run clear when the gun is fired. When the gun is run out, the tackle-falls are to be laid alongside the carriages in neat fakes, that when the gun, by recoiling, overhauls them, they may not get foul, as they would if in a common coil.

6th. *Prime.* If the cartridge is to be pierced with the priming wire, and the vent filled with powder, the pan also is to be filled, and the flat space, having a score through it at the end of the pan, is to be covered; and this part of the priming is to be bruised with the round part of the horn. The apron is to be laid over, and the horn hung up out of danger from the flash of the priming.

7th. *Point your Guns.* At this command the gun is, in the first place, to be elevated to the height of the object by means of the side-sights; and then the person pointing is to direct his fire by the upper sight, having a crow on one side, and a handspike on the other, to heave the gun by his direction till he catches the object. The men who heave the gun for pointing, are to stand between the ship's side, and their crows or handspikes, to escape the injury they might otherwise receive from their being struck against them, or splintered by a shot; and the man who attends the captain with a match is to bring it at the word "point your guns," and kneeling upon one knee opposite the train-truck of the carriage, and at such distance as to be able to touch the priming, is to turn his head from the gun, and keep blowing gently upon the lighted match to keep it clear from ashes. And as the missing of an enemy in action, by neglect, or want of coolness, is most inexcusable, it is particularly recommended to have the people thoroughly instructed in pointing well, and taught to know the ill consequences of not taking proper means to hit their mark; wherefore they should be made to elevate their guns to the utmost nicety, and then to point with the same exactness; and having caught the object through the upper sight, at the word

8th. *Fire,* The match is instantly to be put to the bruised part of the priming, and when the gun is discharged, the vent is to be closed, in order to smother any spark of fire that may remain in the chamber of the gun; and the man who sponges, is immediately to place himself by the muzzle of the gun in readiness, when, at the next word,

9th. *Sponge your Gun,* The sponge is to be rammed down to the bottom of the chamber, and then twisted round, to extinguish effectually any remains of fire; and when drawn out, to be struck against the outside of the muzzle, to shake off any sparks or scraps of the cartridge that may have come out with it; and next its end is to be shifted ready for loading; and while this is doing, the man appointed to provide a cartridge is to go to the box, and by the time the sponge is out of the gun, he is to have it ready; and at the word

10th. *Load with Cartridge,* The cartridge (with bottom end first, seam downwards, and a wad after it,) is to be put into the gun, and thrust a little way within the mouth, when the rammer is to be entered; the cartridge is then to be rammed down, and the captain at the same time is to keep his priming-wire in the vent, and seeing the cartridge, is to give the word "home," when the rammer is to be drawn, and not before. While this is doing, the man appointed to provide a shot is to provide one (or two, according to the order at that time,) ready at the muzzle, with a wad likewise; and when the rammer is drawn, at the word

11th. *Shot your Guns,* The shot, and wad upon it, are to be put into the gun, and thrust a little way down, when the rammer is to be entered as before. The shot and wad are to be rammed down to the cartridge, and there have a couple of forcible strokes, when the rammer is to be drawn, and laid out of the way of the guns and tackles, if the exercise or action is continued; but if it is over, the sponge is to be secured in the place it is at all times kept in.

12th. *Put in your Tompions.* The tompions to be put into the muzzle of the cushion.

13th. *House your Guns.* The seizing is to be put on again upon the clinched end of the breeching, leaving it no slacker than to admit of the gun's being hoisted with ease. The quoin is to be taken from under the breech of the gun and the bed, still resting upon the bolt within the carriage, thrust under till the foot of it falls off the axletree, leaving it to rest upon the end which projects out from the foot. The metal is to be let down upon this. The gun is not to be placed exactly square, and the muzzle is to be close to the wood, in its proper place for passing the muzzle-lashings.

14th. *Secure your Guns.* The muzzle-lashings must first be made secure, and then with one tackle, having all its parts equally taught with the breeching, the gun is to be lashed. The other tackle is to be bowsed taught, and by itself made fast, that it may be ready to cast off for lashing a second breeching. Care must be taken to hook the first tackle to the upper bolt of the carriage, that it may not otherwise obstruct the reeving of the second breeching, and to give the greater length to the end part of the fall. No pains must be spared in bowsing the lashing very taught, that the guns may have the least play that is possible, as their being loose may be productive of very dangerous consequences. The quoin, crow, and handspike, are to be put under the gun; the powder horn hung up in its place, &c.

"Being engaged at any time when there is a large swell, a rough sea, or in squally weather, &c. as the ship may be liable to be suddenly much heeled, the port tackle-fall is to be kept clear, and whenever the working of the gun will admit of it, the man charged with that office is to keep it in his hand; at the same time the muzzle lashing is to be kept fast to the ring of the port, and being hauled taught, is to be fastened to the eye-bolt over the port hole, so as to be out of the gun's way in firing, in order to haul it in at any time of danger. This precaution is not to be omitted when engaging to the windward, any more than when to the leeward, those situations being very subject to alter at too short a warning. A train tackle is always to be made use of with the lee guns, and the man stationed to attend it is to be very careful in preventing the gun's running out at an improper time.

Exercise may also be applied with propriety to the forming a fleet into order of sailing, line of battle, &c. an art which the French have termed evolutions or tactics. In this sense exercise may be defined the execution of the movements which the different orders and dispositions of fleets occasionally require, and which the several ships are directed to perform by means of signals.

EXHAUSTED Receiver, a glass, or other vessel, out of which the air hath been drawn by means of the air-pump. *See* Pneumatics.

EXHAUSTIONS, in Geometry. Method of exhaustions is a way of proving the equality of two magnitudes, by a *reductio ad absurdum*, shewing, that if one be supposed either greater or less than the other, there will arise a contradiction. The method of exhaustions was of frequent use among the ancient mathematicians, as Euclid, Archimedes, &c. It is founded on what the former says in his tenth book, *viz.* that those quantities whose difference is less than any assignable quantity, are equal; for if they were unequal, however small the difference might be, yet it might be so multiplied, as to become greater than either of them, and if not so, then it is really nothing.

EXHIBIT, in Law, is where a writing, being produced in a chancery suit, the commissioner certifies on the back thereof, that the same was shewn to the witness at the time of his examination, and by him sworn to.

EXHIBITION, a benefaction settled for the benefit of scholars in the universities, that are not on the foundation.

EXIGENT, in Law, a writ which lies where the defendant in a personal action cannot be found, nor any effects of his within the country, by which he may be attached or distrained.

EXOCOETUS, or the Flying Fish, in Ichthyology, a genus belonging to the order of abdominales. When pursued by another fish, it raises itself from the water by means of these fins, and flies in the air to a considerable distance, till the fins are dry, and then it falls down into the water. In its own element it is perpetually harassed by the dorados and other fish of prey. If it endeavours to avoid them, by having recourse to the air, it either meets its fate from the gulls or the albatross, or is forced down again into the mouths of the inhabitants of the water, who below keep pace with its aërial excursions. This fish is most common between the tropics.

EXOTIC, an appellation for the produce of foreign countries. Exotic plants of the hot climates are very numerous, and require the utmost attention of the gardener.

EXOTERIC and ESOTERIC, are terms denoting external and internal, and were applied to the double doctrine of the ancient philosophers, the former public and open, and the latter secret, or confined to a select number of disciples.

EXPANSION, in Physics, is the enlargement or increase in the bulk of bodies, in consequence of a change in their temperature. This is one of the most general effects of heat, being common to all bodies whatever, whether solid or fluid. The expansion of solid bodies is determined by the Pyrometer, and that of fluids by the Thermometer. *See* these articles.

The expansion of fluids varies considerably; but, in general, the denser the fluid, the less the expansion: thus, water expands more than mercury, and spirits of wine more than water; and commonly the greater the heat, the greater the expansion; but this is not universal, for there are cases in which expansion is produced, not by an increase, but by a diminution of temperature. Water furnishes us with the most remarkable instance of this kind. Its maximum of density corresponds with 42°.5 of Fahrenheit's thermometer, when cooled down below 42°.5, it undergoes an expansion for every degree of temperature which it loses; and at 32° the expansion amounts to $\frac{1}{160}$ of the whole expansion which water undergoes when heated from 42°.5 to 212°. With this, more recent experiments coincide very nearly; for by cooling 100,000 parts in bulk of water from 42°.5 to 32°, they were converted to 100,031 parts. The expansion of water is the same for any number of degrees above or below the maximum of density. Thus, if we heat water ten degrees above 42°.5, it occupies precisely the same bulk as it does when cooled down ten degrees below 42°.5. Therefore the density of water at 32° and at 53° is precisely the same. Dalton cooled water to the temperature of 5° without freezing, or 37°.5 below the maximum point of density; and during the whole of that range, its bulk precisely corresponded with the bulk of water the same number of degrees above 42°.5.

The prodigious force with which water expands in the act of freezing, is shewn by glass bottles filled with water, which are commonly broken in pieces when the water freezes. A brass globe whose cavity is an inch in diameter, may be burst by filling it with water and freezing it, and the force necessary for this effect is 27,720 this weight. The expansive force of freezing water may be explained, by supposing it the consequence of a tendency which water, in consolidating, is observed to have to arrange its particles in one determinate manner, so as to form prismatic crystals, crossing each other at angles of 60° and 120°. The force with which they arrange themselves in this manner must be enormous, since it enables small quantities of water to overcome so great mechanical pressures. This observation is conspicuously illustrated by observing the crystals of ice on a piece of water exposed to the action of the air in frosty weather; or upon a pane of glass in a window of a room without a fire, at the same season. Various methods have been tried to ascertain the specific gravity of ice at 32°; that which succeeded best was to dilute spirits of wine with water till a mass of solid ice put into it remained in any part of the liquid without either sinking or rising. The specific gravity of such a liquid is 0.92, which of course is the specific gravity of ice, supposing the specific gravity of water at 60° to be 1. This is an expansion much greater than water experiences even when heated to 212°, its boiling point. We see from this, that water, when converted into ice, no longer observes that equable expansion measured by Dalton, but undergoes a very rapid and considerable augmentation of bulk.

EXPARTE, a term used in the Court of Chancery, when a commission is taken out and executed by one side or party only, upon the other parties neglecting or refusing to join therein.

EXPECTATION, in the Doctrine of Chances, is the value any prospect of prize or property depending upon the happening of some uncertain event, the value of which in all cases is equal to the whole sum multiplied by the probability that the event on which it depends may happen.

Expectation, in the Doctrine of Life Annuities, denotes that particular number of years which a life of a given age has an equal chance of enjoying, or the time which a person of a given age may justly expect to live. But Simpson has shewn that this period does not coincide with that which writers on annuities call the expectation of life, except on a supposition of a uniform decrease in the probabilities of life; and Dr. Price adds, that even on this supposition it does not coincide with what is called the expectation of life, in any case of joint lives. *See* Survivorship. The expectation of life coincides with the sums of the present probabilities, that any single or joint life shall attain to the end of the first, second, third, &c. moments from this time to the end of their possible existence, or in case of survivorships, with the sum of the probabilities, that there shall be a survivor at the expiration of those periods. From which principles Dr. Price has shewn how Demoivre deduced his rules for determining the expectation of any given life. Simpson's Table of the Expectation of Life in London, is as follows:

Age.	Expectation.	Age.	Expectation.	Age.	Expectation.	Age.	Expectation.
1	27·0	21	28·3	41	19·2	61	12·0
2	32·0	22	27·7	42	18·8	62	11·6
3	34·0	23	27·2	43	18·5	63	11·2
4	35·6	24	26·6	44	18·1	64	10·8
5	36·0	25	26·1	45	17·8	65	10·5
6	36·0	26	25·6	46	17·4	66	10·1
7	35·8	27	25·1	47	17·0	67	9·8
8	35·6	28	24·6	48	16·7	68	9·4
9	35·2	29	24·1	49	16·3	69	9·1
10	34·8	30	23·6	50	16·0	70	8·8
11	34.3	31	23·1	51	15·6	71	8·4
12	33·7	32	22·7	52	15 2	72	8·1
13	33·1	33	22·3	53	14·9	73	7·8
14	32·5	34	21·9	54	14·5	74	7·5
15	31·9	35	21·5	55	14·2	75	7·2
16	31·3	36	21.1	56	13·8	76	6·8
17	30·7	37	20·7	57	13·4	77	6·4
18	30·1	38	20·3	58	13·1	78	6 0
19	29·5	39	19·9	59	12·7	79	5·5
20	28·9	40	19·6	60	12·4	80	5.0

From this table, the expectation of life, at any age, is found on inspection; thus, a person of 20 years of age has an expectation of living 28·9 years, and in the same manner may be found the expectation at any other age.

EXPECTORANTS, in Pharmacy, medicines which promote expectoration; such are the stimulating gums and resins, squills, &c.

EXPECTORATION, the act of evacuating or bringing up phlegm, or other matters, out of the trachea and lungs, by coughing, &c.

EXPERIMENT, in Philosophy, is a trial of the effect or result of certain applications and motions of natural bodies, in order to discover their natures, laws, relations, &c.

EXPERIMENTAL Philosophy, is that which deduces the laws of nature, the properties and powers of bodies, and their actions upon each other, from sensible experiments and observations. In our inquiries into nature, we are to be guided by those rules and maxims which are found genuine, and consonant to a just method of physical reasoning; and these rules are by Sir Isaac Newton reckoned four, *viz.* 1. More causes of natural things are not to be admitted, than are true, and sufficient to explain the phenomena; for nature is simple, and does nothing in vain. 2. Therefore of natural effects of the same kind, the same causes are to be assigned, as far as it can be done; as of respiration in man and beasts, of the descent of stones in Europe and America, of light in a culinary fire and in the sun, and of the reflection of light in the earth and the other planets. 3. The qualities of natural bodies which cannot be increased or diminished, and agree to all bodies on which experiments can be made, are to be reckoned as the qualities of all bodies whatever; thus, because extension, divisibility, hardness, impenetrability, mobility, the vis inertia, and gravity, are found in all bodies under our inspection, we may conclude that they belong to all bodies whatever, and of which they are the original and universal properties. 4. In experimental philosophy, propositions collected from the phenomena by induction, are to be deemed (notwithstanding contrary hypotheses) either exactly, or very nearly true, till other phænomena occur, by which they may be rendered more accurate, or liable to exception. This ought to be done, lest argument of induction should be destroyed by hypotheses, and logical series be superseded by conjectures.

EXPERIMENTUM CRUCIS, a leading or decisive experiment, is so termed on account of its being like a cross, placed in the meeting of several roads, guiding men to the true knowledge of what they are inquiring after; or on account of its being a kind of torture, whereby the nature of the thing is discovered by force.

EXPLOSION, in Natural Philosophy, a sudden and violent expansion of an aërial or other elastic fluid, by which it instantly throws off any obstacle in its way. Explosion differs from expansion in this; that the latter is a gradual power, acting uniformly for some time, whereas the former is momentary. The expansions of solid substances do not terminate in violent explosions, on account of their slowness, and the small space through which the expanding substance moves. Thus we find, that though wedges of wood, when wetted, will cleave solid blocks of stone, they never throw them to any distance, as gunpowder does. On the other hand, it is seldom that the expansion of any elastic fluid bursts a solid substance, without throwing the fragments of it to a considerable distance. The reasons of this may be comprised in these particulars: 1. The immense velocity with which the aërial fluids expand, when affected by a considerable degree of heat. 2. Their celerity in acquiring heat, and being affected by it, which is much superior to that of solid substances. Thus air, heated as much as iron when brought to a white heat, is expanded to four times its bulk: but the metal itself will not be expanded the 500th part of that space. In the case of gunpowder, the velocity with which the flame moves is calculated by Mr. Robins, to be no less than 7000 feet in a second, or little less than 70 miles per minute. Hence the impulse of the fluid is inconceivably great, and the obstacles on which it strikes are carried off with vast velocity, though much less than that just mentioned; for a cannon-ball, with the greatest charge of powder, does not move at a greater rate than 2400 feet per second, or little more than 27 miles per minute. The velocity of the ball again is promoted by the sudden propagation of the heat through the whole body of the air, as soon as it is extricated from the materials of which the gunpowder is made, so that it is enabled to strike all at once, and thus greatly to augment the movements of the ball. We may conclude, upon these principles, that the force of an explosion depends, 1. on the the quantity of elastic fluid to be expended; 2. on the velocity it acquires by a certain degree of heat; and 3. on the celerity with which the degree of heat affects the whole of the expansile fluid. These three take place in the greatest perfection where the electric fluid is concerned, as in lightning, earthquakes, and volcanoes. *See* STEAM.

EXPONENT, in Algebra, a number placed over any power or involved quantity, to shew to what height the root is raised; thus the number 2 is the exponent of x^2, and 4 the exponent of x^4, or $x x x x$.

EXPORTATION, in Commerce, the art of sending goods out of one country into another.

EX POST FACTO, in Law, something done after another; thus, a law is said to be *ex post facto* when it is enacted to punish an offence committed before the passing of the law; a violation of the plainest principles of justice.

EXPRESSED OILS, in Chemistry, are those which are obtained from bodies only by pressing, to distinguish them from animal and essential oils, which last are for the most part obtained by distillation.

EXTENSION, in Philosophy, one of the common and essential properties of body, or that by which it possesses or takes up some part of universal space.

EXTENT, in Law, signifies a writ or command to the sheriff, for the valuing of lands or tenements; and sometimes the act of the sheriff, or other commissioner, upon this writ: but most commonly it denotes an estimate or valuation of lands, and hence come our extended or rack rents.

EXTERMINATION, in general, the extirpating or destroying something. In Algebra, surds, fractions, and unknown quantities, are exterminated by the rules observed for reducing equations.

EXTRA JUDICIAL, in Law, is when judgment is given in a cause or case not depending in that court where such judgment is given, or wherein the judge has no jurisdiction, or legal authority.

EXTRA *Parochial*, out of any parish; privileged or exempted from the duties of a parish.

EXTRACT, in Pharmacy, is a solution of the purer parts of a mixed body inspissated, by distillation or evaporation, nearly to the consistence of honey.

EXTRACT, exists in almost all plants, and consists principally of astringent matter, and extract; by the action of water upon it, the astringent matter is first dissolved, and may be separated from the extract. Extract is always more or less coloured; it is soluble in alcohol and water, but not soluble in ether. It unites with alumina when that earth is boiled in a solution or extract; and it is precipitated by the salts of alumina, and by many metallic solutions, particularly the solution of muriate of tin. From the products of its distillation, it seems to be composed principally of hydrogen, oxygen, carbon, and a little azote.

EXTRACTION OF THE SQUARE ROOT. Extracting the square root is to find out such a number as, being multiplied into itself, the product will be equal to the given number. *Rule* 1. Point the given number, beginning at the unit's place, then to the hundreds, and so upon every second figure throughout. 2. Seek the greatest square number in the first point towards the left-hand, placing the square number under the first point, and the root thereof in the quotient; subtract the square number from the first point, and to the remainder bring down the next point, and call that the *Resolvend*. 3. Double the quotient, and place it for a divisor on the left-hand of the resolvend; seek how often the divisor is contained in the resolvend, (preserving always the unit's place,) and put the answer in the quotient, and also on the right-hand side of the divisor; then multiply by the figure last put in the quotient, and subtract the product from the resolvend; bring down the next point to the remainder, (if there be any more) and proceed as before.

Roots,	1.	2.	3.	4.	5.	6.	7.	8.	9.
Squares,	1.	4.	9.	16.	25.	36.	49.	64.	81.

Example. What is the square root of 1 19025?

```
     119025(345  Ans.
      9
     ___
  64) 590
      256
      ____
 685) 3425
      3425
      ____
```

To Extract the Square Root of simple Algebraic Quantities.—Extract the root of the co-efficient for the numerical part, and divide the index of the letter, or letters, by the exponent of the proposed root, and it will give the answer required. Thus the square root of $9x^2 = 3x^2 = 3x$; and the cube root of $8x^3 = 2x$.

To find the Root of Compound Quantities, proceed as in common arithmetic, ranging the quantities according to the dimensions of one of the letters, and proceed as under:

Ex. 1. Extract the square root of $x^4 - 4x^3 + 6x^2 - 4x + 1$.

$x^4 - 4x^3 + 6x^2 - 4x + 1\ (x^2 - 2x + 1 =$ *root*
x^4
$2x^2 - 2x) - 4x^2 + 6x^2$
$\quad - 4x^3 + 4x^2$
$2x^2 - 4x + 1)\ 2x^4 - 4x + 1$
$\quad 2x^2 - 4a + 1$

2. Extract the square root of $4a^4 + 12a^3x + 13a^2x^2 + 6ax^3 + x^4$

$4a^4 + 12a^3x + 13a^2x^2 + 6ax^3 + x^4\ (2a^2 + 3ax + x^2$
$4a^4$
$4a^2 + 3ax)\ 12a^3x + 31a^2x^2$
$\quad 12a^3x + 9a^2x^2$
$4a^2 + 6ax + x^2)\ 4a^2x^2 + 6ax^3 + x^4$
$\quad 4a^2x^2 + 6ax^3 + x^4$

To find the Roots of Powers in general.—Find the root of the first term, and place it in the quotient; subtract its power from that term; then bring down the second term of the dividend. Involve the root, last found, to the next *lowest* power, and multiply it by the index of the given power for a divisor; divide the dividend by this divisor, and the quotient will be the next term of the root. Involve now the whole root, and subtract and divide as before; and so on till the whole is finished.

Ex. 1. Required the square root of $a^4 - 2a^3x + 3a^2x^2 - 2ax^3 + x^4$.

$a^4 - 2a^3x + 3a^2x^2 - 2ax^3 + x^4\ (a^2 - ax + x^2$
a^4
$2a^2) - 2a^3x$
$a^4 - 2a^3x + a^2x^2 = (a^2 - ax)^2$
$2a^2)\ 2a^2x^2$
$a^4 - 2a^3x + 3a^2x^2 - 2ax^3 + x^4 = (a^2 - ax + x^2)^2$

Ex. 2. Extract the cube root of $x^6 + 6x^5 - 40x^3 + 96x = 64$.

$x^6 + 6x^5 - 40x^3 + 96x - 64\ (x^2 + 2x - 4$
x^6
$3x^4)\ 6x^5$
$x^6 + 6x^5 + 12x^4 + 8x^3 = (x^2 + 2x)^3$
$3x^4) - 12x^4$
$x^6 + 6x^5 - 40x^3 + 96x - 64 = (x^2 + 2x - 4)^3$

EXTRACTION *of the Cube Root.* To extract the cube root is to find out a number, which being multiplied into itself, and then into that product, produceth the given number. *Rule* 1. Point every third figure of the cube given, beginning at the unit's place; seek the greatest cube to the first point, and subtract it therefrom; put the root in the quotient, and bring down the figures in the next point to the remainder for a *resolvend.* 2. Find a *divisor*, by multiplying the square of the quotient by 3. See how often it is contained in the resolvend, rejecting the units and tens, and put the answer in the quotient. 3. To find the *subtrahend.* 1. Cube the last figure in the quotient. 2. Multiply all the figures in the quotient by 3, except the last, and that product by the square of the last. 3. Multiply the divisor by the last figure: Add these products together, and they will give the subtrahend; which subtract from the resolvend; to the remainder bring down the next point, and proceed as before.

Roots.	1.	2.	3.	5.	6.	7.	8.	9.
Cubes.	1.	8.	27.	125.	216.	343.	512.	729.

Example. What is the cube root of 99252847?

$\dot{9}92\dot{5}28\dot{4}7$ (463
Divisor, 64 = cube of 4.
Square of 4 × 3 = 48) 35252 resolvend.
216 = cube of 6.
432 = 4 × 3 × by square of 6
288 = divisor × by 6
Divisor, 33336 subtrahend.
Square of 46 × 3 = 6348) 1916847 resolvend.
27 = cube of 3.
1242 = 46 × 3 × by square of 3.
19044 = divisor × by 3.
1916847 subtrahend.

A more Concise Method of Extracting the Cube Root.—*Rule* 1. Point every third figure of the cube given, beginning at the unit's place, then find the highest cube to the first point, and subtract it therefrom, put the root in the quotient, bring down the figures in the next point to the remainder for a resolvend.—2. Square the quotient, and triple the square for a divisor. As 4 × 4 × 3 = 48. Find how often it is contained in the resolvend, rejecting units and tens, and put the answer in the quotient.—3. Square the last figure in the quotient, and put it on the right-hand of the divisor. As 6 × 6 = 36 put to the divisor 4 8 = 48 36.—4. Triple the last figure in the quotient, and multiply by the former, put it under the other, units under the tens, add them together, and multiply the sum by the last figure in the quotient, subtract that product from the resolvend, bring down the next point, and proceed as before.

Example. What is the cube root of 99252847?

The square of 4 × 3 = 48 divisor. 99252847 (463
The square of 6 put to 48 = 4836 64
6 × 3 × 4 72x 35252
5556 × 6 = 3336
1916847

The square of 46 = 2116 × 3 = 6348 divisor.
The square of 3 = 9 put to 6348 = 634809
3 × 3 × 46 = 414
638949 × 3 = 1916847
......

Hence the cube root of 99252847 = 463
for 463 × 463 × 463 = 99252847

Another, and a very simple method of extracting the cube root, is as follows: Point off the given number in periods of three figures, beginning at the unit's place. Find the root of the last period, *i.e.* the period on the left-hand side of the number; subtract this root, as in the following example, where 64 is taken from 99; to the remainder 35 bring down the next period 252, and seek a divisor by multiplying the square of the quotient 4 (*i.e.* 16) by 300, and the product 4800 will be the new divisor, which is contained in 35252 six times; set this 6 in the quotient. Bring down the two periods 99 and 252 into one sum 99252; now cube the quotient 46, and place its product 97336 under the dividend; subtract the cube from this dividend, and to the remainder 1916, bring down the next period in the dividend, *viz.* 847; square the quotient 46, multiply this square by 300 for a divisor, find how often it is contained in 1916847, *viz.* three times; set this 3 in the quotient. Bring down the whole dividend 99,252,847, cube the quotient 463, and subtract its product as before, and so on till the dividend is exhausted:—

$$\begin{array}{rl} \text{Thus:} & 99|252|847\,(463 \\ & 64 \\ \hline 4^2 \times 300 = 4800 & 35252\,(6 \\ & 28800 \\ \hline & 99252 \\ 46^3 = & 97336 \\ \hline \overline{46}|^2 \times 300 = 634800 & 1916847\,(3 \\ & 1904400 \\ \hline & 99252847 \\ \overline{463}|^3 = & 99252847 \\ \hline & \ldots\ldots\ldots \end{array}$$

EXTRACTOR, in Midwifery, an instrument, or forceps, for extricating children by the head.

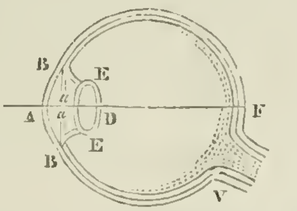
EXTRADOS, the outside of an arch of a bridge, vault, &c. *See* Bridge.

EXTRAVASATION, in contusions, and other accidents of the cranium, is when one or more of the blood-vessels distributed on the dura mater, are broken, whereby there is such a discharge of blood as oppresses the brain, frequently bringing on violent pains, and at length death itself, unless the patient is timely relieved.

EXTREME and Mean Proportional. *See Proportional.*

EXTREMES, Conjunct and Disjunct, in Spherical Trigonometry, are, the former, the two circular parts that lie next the middle part, and the latter, the two that lie remote from the middle part. These were the terms applied by Napier in his universal theorem, commonly called Napier's Circular Parts.

EXUVIÆ, among naturalists, denotes the cast-off parts or coverings of animals, as the skins of serpents, caterpillars, and other insects.



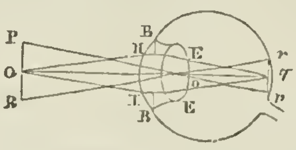
EYE, the organ of sight, consisting of several parts, so adapted to each other as to answer the purpose of distinct vision when placed in a proper situation with regard to light and shade. The eye, though properly a subject of anatomy, is so connected with the doctrine of vision, that its structure must first be understood before any advances can be made in that theory, and as such it becomes a matter of philosophical inquiry and must not therefore be wholly omitted in the present work, although our limits will only admit of a brief illustration of its construction and principal mode of operation. The annexed figure represents a section of the human eye, made by a plane, which is perpendicular to the coats which contain its several humours, and also to the nose. Its form is nearly spherical, and would be exactly so, were not the forepart a little more convex than the remainder; the parts B F B, B A B, are, in reality, segments of a greater and less sphere. The humours of the eye are contained in a firm coat B F, B A, called the *sclerotica;* the more convex or protuberant part of which, B A B, is transparent, and, from its consistency and horny appearance, it is called the *cornea*. This coat is represented by the space contained between the two exterior circles B F, B A. Contiguous to the sclerotica is a second coat, of a softer substance, called the *choroeides;* this coat is represented by the next white space, and extends along the back part of the sclerotica to the cornea. From the junction of the choroeides and cornea, arises the *uvea*, B *a*, B *a*, a flat opaque membrane, in the forepart of which, and nearly in its centre, is a circular aperture called the *pupil*. The pupil is capable of being enlarged or contracted with great readiness; by which means, a greater or less number of rays may be admitted into the eye, as the circumstances of vision require. In weak light, too few rays might render objects indistinct; and in a strong light, too many might injure the organ. Whilst the pupil is thus enlarged or contracted, its figure remains unaltered. This remarkable effect is thought to be produced by means of small fibres which arise from the outer circumference of the uvea, and tends towards its centre; this circumference is also supposed to be muscular, and by its equal action upon the fibres, on each side, the form of the pupil is preserved, whilst its diameter is enlarged or contracted.

At the back part of the eye, a little nearer to the nose than the point which is opposite to the pupil, enters the *optic nerve* V, which spreads itself over the whole of the choroeides like a fine net, and from this circumstance is called the *retina*. It is immersed in a dark mucus, which adheres to the choroeides. These three coats, the sclerotica, the choroeides, and the retina, enter the socket of the eye at the same place. The sclerotica is a continuation of the *dura mater*, a thick membrane which lies immediately under the scull. The choroeides is a continuation of the *pia mater*, a fine thin membrane which adheres closely to the brain. The retina proceeds from the brain.

Within the eye, a little behind the pupil, is a soft transparent substance, E D E, nearly of the form of a double convex lens, the anterior surface of which is less curved than the posterior, and rounded off at the edges, E, E, as the figure represents. This humour, which is nearly of the consistency of a hard jelly, decreasing gradually in density from the centre to the circumference, is called the *crystalline humour*. It is kept in its place by a muscle called the *ligamentum ciliare*, which takes its rise from the junction of the choroeides and cornea, and is a little convex towards the uvea. The cavity of the eye, between the cornea and crystalline humour, is filled with transparent fluid like water, called the *aqueous humour*. The cavity between the crystalline humour and the back part of the eye, is also filled with a transparent fluid, rather more viscous than the former, called the *vitreous humour*.

It is not easy to ascertain, with great accuracy, the refracting powers of the several humours; the refracting powers of the aqueous and vitreous humours are nearly equal to that of water; the refracting power of the crystalline humour is somewhat greater. The surfaces of the several humours of the eye are so situated as to have one line perpendicular to them all. This line, A D F, is called the *axis of the eye*, or *optic axis*.

The *focal centre of the eye*, is that point in the axis at which the image upon the retina and the object subtend equal angles, This point is not far distant from the posterior surface of the crystalline lens, though its situation is probably subject to a small change, as the figure of the eye, or the distance of the object, is changed.



From the consideration of the structure of the eye, we may easily now understand how the notices of external objects are conveyed to the brain. Let P Q R, in the annexed figure, be an object, towards which the axis of the eye is directed; then the rays which diverge from any point Q, and fall upon the convex surface of the aqueous humour, have a degree of convergency given them; they are then refracted by a double convex lens, denser than the ambient mediums, which increases the convergency; and if the extreme rays Q H, Q I, have a proper degree of divergency before incidence, the pencil will be again collected upon the retina, at *q*, and there form an image of Q. In the same manner, the rays which diverge from any other points, P, R, in the object, will be collected at the corresponding points, *p*, *r*, of the retina, and a complete image, *p*, *q*, *r*, of the object P Q R, will be formed there. The impression thus made, is conveyed to the brain by the optic nerve, which originates there, and is evidently calculated to answer this purpose.

Here it will be observed, that since the axis of the several pencils cross each other at O, the focal centre of the eye, the image upon the retina is inverted with respect to the object, and yet it furnishes the mind with the idea of its being erect. This is a difficulty that has produced considerable discussion amongst philosophers, and the most satisfactory explanation which can probably be given is, that experience *alone* teaches us what situation of an external object corresponds to a particular impression upon the retina. Some opticians, however, are unwilling to concede this point, and contend that the object is reflected from the retina to another substance on which they are painted, and thus give to the eye exactly the construction of a Gregorian telescope.

The following measure of the crystalline and cornea, were taken by Dr. Gordon and Dr. Brewster, from the eye of a female above 50 years of age, a few hours after death.

Diameter of the crystalline, ...	0·378
Diameter of the cornea, ...	0·400
Thickness of the crystalline,..................	0·172
Thickness of the cornea, ...	0·042

Measures of the refractive powers of the humours of the same eye:—

	Index of Refraction.
Refractive power of water,.................	1·3358
Ditto, of aqueous humour,.................	1·3366
Ditto, of vitreous humour,.................	1·3394
Ditto, of outer coat of crystalline,...........	1·3767
Ditto, of middle coat of ditto, ...	1·3786
Ditto, of central part of ditto, ...	1·3990
Ditto, of the whole crystalline,..............	1·3839

The range of the eye, or the field of vision, may be taken at 110 degrees.

Eye, in Architecture, is used to signify any round window made in a pediment, an attic, the reins of a vault, or the like.

Eye *of a Dome*, an aperture at the top of a dome, as that of the Pantheon at Rome, or of St. Paul's at London: it is usually covered with a lantern.

Eye, in Agriculture and Gardening, signifies a little bud, o shoot, inserted into a tree by way of graft.

Eye *of a Tree*, a small pointed knot to which the leaves stick, and from which the shoots or sprigs proceed.

Eye *of a Block Strop*, is that part by which it is fastened or suspended to any particular place upon the sails, masts, or rigging; the eye is sometimes formed by making two eye-splices on the ends of the strop, and then fastening them together with a small line, so as to bind round a mast, yard, or boom, as is deemed necessary.

Eye *of a Stay*, that part of a stay which is formed into a sort of collar to go round the mast-head.

Flemish Eye, is a phrase particularly applied to the eye of a stay, which is either formed at the making of the rope, or by dividing the yarns into two equal parts, knotting each pair separately, and pointing the whole over.

Eye-*Bolt*, a long bar of iron, with an eye in one end of it, formed to be driven into the decks, sides, &c. for the purpose of fastening ropes, or hooking tackles to.

Eyes *of a Ship*, a name frequently given to those parts which lie near the bawse holes, particularly in the lower apartments within the vessel.

EYELET Holes, round holes worked in a sail, to admit a small rope through, chiefly the robins (or rope-bands), and the points or reef-line.

F.

F, the sixth letter of the Alphabet. As a numeral it denotes 40, and with a dash over it thus F 40,000. In Music it stands for the bass-clef, and frequently for forte, as *ff* does for forte forte. F, in Medicine, stands for *fiat*, let it be done.

FA, in Music, one of the syllables invented by Guido Aretine, to mark the fourth note of the modern scale which rises thus, ut, re, mi, fa. Musicians distinguish two fa's, *viz.* the flat, marked thus ♭; the sharp, marked thus ♯; and the natural, marked thus ♮; and called biquadro. *Fa finto*, a feigned F, or a feint upon that note.

FABLE, a tale or feigned narration, designed either to instruct or amuse, disguised under the allegory of an action.

Fable is also used for the plot of an epic or dramatic poem; and is, according to Aristotle, the principal part, and the soul of a poem.

FACE of a Stone, in Masonry, that superficies of it which lies in the front of the work. The workmen generally chuse to make one of those sides the face, which, when in the quarry, lay perpendicularly to the horizon, and consequently the breaking, not the cleaving way of the stone.

FACET, or Facette, among jewellers, the name of the little faces or planes in brilliant and rose diamonds.

FACTITIOUS, any thing made by art, in opposition to what is the produce of nature. Thus, factitious cinnabar is opposed to native cinnabar.

FACTOR, in Arithmetic, a name given to the multiplier and multiplicand, because they constitute the product.

Factor, in Commerce, an agent employed by a merchant or merchants, to sell goods, or buy goods, at some remote or foreign place, and to negotiate bills, &c. upon a certain fixed allowance or commission. The supercargo and factor differ in this; the supercargo takes care of goods which he accompanies to some destined place, and then returns to his employers: The factor resides abroad, and executes business for different merchants. But their duties, and the circumstances for which they are accountable, are the same. They procure the best intelligence of the markets; execute their business with all the despatch possible; are punctual in their correspondence; act under absolute or limited power; but it is incumbent on the employer, if he challenge his factor's proceedings, to prove that he could himself have done better. And a factor is never warranted to deal or trust with any persons, unless allowed by his employers, and with persons of good credit. In case of bankruptcies, a factor can lay attachments, and advise his employers thereof. Goods seized through his negligence, he must pay for. If a factor become insolvent, his employers, not his creditors, recover the prices of all goods sold by him for the said employers. There are various other duties too tedious to mention, which belong to the office of factor, and which can only be known from practice.

FACTORAGE, called also *Commission*, is the allowance given by merchants to the factors whom they employ. In Britain it is about 2½ per cent; in Italy 2½; in Spain, France, Holland, Dantzic, Portugal, 2 per cent.; in Turkey, 3 per cent.; in North America 5 per cent. on sales, and 5 per cent. on returns. In the West Indies 8 per cent on sales and storage, &c.

FACTUM, is the product arising from the multiplication of several factors; thus 35 is the factum of 5 times 7.

FACULTY, a privilege granted to a person doing what, by law, he ought not to do. For granting these privileges, there is a court under the archbishop of Canterbury, called the court of the faculties.

Faculty, in the Schools, a term applied to the different members of an university, according to the arts and sciences taught there; as 1. Arts. 2. Theology. 3. Physic. And 4. Civil Law.

Faculty *of Advocates*, a term applied to the college or society of advocates in Scotland, who plead in all actions before the Court of Session. They meet in the beginning of every year, and choose the annual officers of the society, *viz.* dean, treasurer, clerks, private and public examinators, and a curator of the library.

Faculty is also used to denote the powers of the human mind, *viz.* understanding, will, memory, and imagination.

FÆCES, in Chemistry, the gross matter, or sediment, that settles at the bottom after distillation, fermentation, &c.

FAGARA, *Ironwood*, a genus of the monogynia order, in the tetandria class of plants, and in the natural method ranking under the 43d order, dumosæ. There are 10 species, all natives of America, rising with woody stems more than 20 feet high.

FAGNANO, Jules Charles, a distinguished Italian mathematician, born about the year 1690, early in the eighteenth century published several memoirs, in the Italian journals, on the transcendental analysis; there are also many pieces of the same author in the Leipsic Acts, which were afterwards published by himself, with some other papers, under the title of "Mathematical Productions;" Pesaro, 4to. 1750.

FAGUS, the *Beech Tree*, a genus of the polyandria order in the monœcia class of plants; and in the natural method ranking under the 50th order, amentaceæ. There are five species. The most remarkable are; 1. The sylvatica, or beech tree, which rises 60 or 70 feet high, and has a proportionable thickness. 2. The castanea, or chestnut tree, has a large upright trunk growing 40 or 50 feet high. 3. The pumila, dwarf chestnut tree, or chinkapin, rises eight or ten feet high.

FAIR, a greater kind of Market granted to a town, by privilege, for the more speedy and commodious buying and selling, or providing such things as the place stands in need of. It is incident to a fair, that persons should be free from being arrested in it for any debt, except that which has been contracted in the same; or, at least, promised to be paid there. These fairs are usually held twice a year, in some places only once a year; and by statute, they shall not be held longer than they ought by the lords thereof, on pain of their being seized into the king's hands, &c. Also proclamation is to be made, how long they are to continue; and no person shall sell any goods after the fair is ended, on forfeiture of double the value, one-fourth to the prosecutor, and the rest to the king. There is a toll usually paid at fairs, for the privilege of erecting stalls from which to sell goods, as well as booths, either for entertaiment or pastime.

FAIR, a general term for the disposition of the wind when it is favourable to a ship's course, in opposition to what is contrary or foul. This term, when applied to the wind, is much more comprehensive than *Large*, since the former seems to include about eighteen points of the compass, or at least sixteen, whereas *Large* is confined to the beam or quarter, that is, to a wind which crosses the keel at right angles, or obliquely from the stern, but never to one right astern. *See* the articles LARGE and SCANT.

FAIR *Curve*, in delineating ships, is a winding line, whose shape is varied according to the part of the ship it is intended to describe. This curve is not answerable to any of the figures of conic sections, although it occasionally partakes of them all.

FAIR *Way*, the channel of a narrow bay, river, or harbour, in which ships usually pass in their way up and down; so that if any vessels are anchored therein, they are said to lie in the fair way.

FAIRY CIRCLE, or RING, a phenomenon frequent in the fields, &c. supposed by the vulgar to be traced by the fairies in their dances: there are two kinds, one of about seven yards in diameter, containing a round bare path a foot broad, with green grass in the middle of it. The other is of different bigness, encompassed with a circumference of grass, greener and fresher than that in the middle. Some attribute them to lightning; and others to a kind of fungus which breaks and pulverizes the soil.

FAKE, one of the circles or windings of a cable or hawser, as it lies disposed in a coil. The fakes are greater or smaller, in proportion to the extent or space which a cable is allowed to occupy where it lies.

FALCADE, in the Manege, the motion of a horse when he throws himself upon his haunches several times in very quick curvets, which is done in forming a stop and half stop.

FALCATED, horned, as the moon in the 1st and 3d quarter.

FALCO, a genus of birds belonging to the order of accipitres. The eagle, kite, and hawk, form this genus; of which there are 32 species. 1. The leucocephalus, bald, or white-headed eagle, is ash-coloured, with head and tail white. 2. The ossifragus, sea-eagle, or osprey, with yellow wax, and half-feathered legs, is about the size of a peacock; the feathers are white at the base, iron-coloured in the middle, and black at the points; and the legs are yellow. 3. The charysaëtos, or golden eagle, weighs about twelve pounds, and is in length about three feet, the wings when extended measuring about seven feet four inches. The sight and sense of smelling are very acute: the head and neck are clothed with sharp-pointed feathers, of a deep brown colour, bordered with tawny; the hind part of the head in particular is of a bright rusty colour. 4. The cyaneus, or hen-harrier, with white wax, yellow legs, a whitish-blue body, and a white ring round the eyes and throat. 5. The albicilla, or cinereous eagle, is inferior in size to the golden eagle; the head and neck are of a pale ash-colour, the body and wings cinereous, coloured with brown; the quill feathers very dark; the tail white; the legs feathered but little below the knees, and of a very bright yellow. 6. The maculatus, or crying eagle, is in colour of a ferruginous brown; the coverts of the wings and scapulars are varied with white spots; the primaries dusky, the ends of the greater white; the breast and belly of a deeper colour than the rest of the plumage, streaked with dull yellow; the tail is dark brown, tipt with dirty white; the legs are feathered to the feet, which are yellow. The length of the bird is two feet. 7. The milvus, or kite, is a native of Europe, Asia, and Africa. This species generally breeds in large forests or woody mountainous countries. Its nest is composed of sticks, lined with rags, bits of flannel, rope, and paper. Its motion in the air distinguishes it from all other birds, being scarcely perceptible. Sometimes it will remain quite motionless for a considerable space; at others, glide through the sky without the least apparent action of its wings. They inhabit the north of Europe, as high as Jalsberg, in the south of Norway. 8. The gentilis, or gentil falcon, inhabits the north of Scotland, and was in high esteem in the days of falconry. 9. The subbuteo, or hobby, was used in falconry; particularly in what was called daring of larks. 10. The buteo, or buzzard, the most common of the hawk kind in England, breeds in woods, and usually builds on an old crow's nest, which it enlarges, and lines with wool and other soft materials. 11. The tinnunculus, or kestrel, breeds in the hollows of trees, in the holes of high rocks, towers, and ruined buildings. 12. Heliætus, the fishing-hawk of Catesby, called the osprey, measures, from one end of the wing to the other, five feet and a half, is a species of vast quickness of sight; and will see a fish near the surface from a great distance, descend with rapidity, and carry the prey with an exulting scream high into the air. The bald eagle hears the note, and instantly attacks the hawk, who drops the fish, which the former catches before it can reach the ground or water. Besides these, there are some other species distinguished by ornithologists, but which it is unnecessary to particularize here.

FALCONRY, the exercise of taking wild fowl by means of hawks. The falcons or hawks that were in use in these kingdoms are now found to breed in Wales, and in North Britain and its isles. The peregrine falcon inhabits the rocks of Caernarvonshire. The same species, with the gyr-falcon, the gentil, and the gos-hawk, are found in Scotland, and the lanner in Ireland. This diversion, though very ancient, and in such high request, that many of the gentry and nobility hold their estates of the crown on condition of supplying the king with hawks, is now disused.

FALLING STAR, in Meteorology, a phenomenon that is frequently seen, and which has been usually supposed to depend on the electric fluid. Sir Humphrey Davy, in a lecture delivered at the Royal Institution, gave many reasons against this opinion: he conceives that they are rather to be attributed to falling stones. It is observable, that when their appearance is frequent, they have all the same direction; and it has been remarked, that they are the forerunners of a westerly wind in our country.

FALLOPIAN TUBES, in Anatomy, are two ducts arising in the womb, one on each side of the fundus, and thence extended to the ovaries: these have their name from their resemblance to a trumpet, and that of Gabriel Fallopius, a physician of Italy, in the 16th century, who is reported to have first ascertained the use and office of these tubes.

FALLOW LAND, is ground that has been left untilled for a time, in order that it may recover itself from an exhausted state; but to render a barren soil fertile, it ought to be frequently turned up to the air, and to have mixed with it manures of animal dungs, decayed vegetables, lime, marl, sweepings of streets, &c. In turning over the soil, the chief implements of the gardener are the spade, the hoe, and the mattock; and those of the farmer, are the plough, the harrow, the roller, the scythe, and the sickle. And as a succession of the same crops tends to impoverish the soil, a rotation of different crops is necessary. Potatoes, grain, and white crops, are exhausting; but after them, the soil is ameliorated by tares, turnips, and green or plant crops. On stiff soils, clover, beans, wheat, cabbages, and oats, may be cultivated in succession; and on light soils, potatoes, turnips, pease, oats, and barley, may succeed each other. The general rule is, one crop for man, and one for beast. This plan of varying the crops is a new discovery. Formerly, land lay long in fallow; that is to say, was not worked every third or fourth year; but now it is usual, by varying the crops, to get two, three, or four, crops in a year from the same soil, without its being exhausted; and fallowing is, consequently, found to be unnecessary.

FALSETTO, that species of voice in a man, the compass of which lies above his natural one, and is produced by constraint.

FALSE Imprisonment, in Law. To constitute the injury of false imprisonment, two points are necessary: the detention of the person, and the unlawfulness of such detention. Every confinement of the person is imprisonment, whether in a common prison, or a private house, or even by forcibly detaining one in the streets or highways.

FARINA Fœcundans, in Botanical language, the dust on the apices or antheræ of flowers, which being received into the pistil, or seed-vessel of plants, fecundates the rudiments of the seeds in the ovary, which would otherwise come to nothing.

FARM, a Messuage, or district containing house or land, with other conveniences, hired or taken by lease, either in writing or parole, under a certain yearly rent. Farms vary in size, from fifty to one thousand acres. Arable farms are generally smaller than those employed in pasture, or grazing. These, from two to four hundred acres, are the most beneficial to the occupiers and the public. Farmers are called *arable farmers*, when they are chiefly employed in raising corn; and *pasture* or *grass farmers*, when they are engaged in rearing and fattening sheep, and other live stock. Farms are either laid out according to the taste of the owners or occupiers, in all the simplicity of pastoral poetry; or in such an assortment of tillage, arable land, woods, coppices, &c. as convey a distinct notion of the pure Arcadian demesne; or as a simple farm laid out with a sufficient adaptation of wood and water, of arable and pasture land, outhouses, cottages, and other improvements suggested by extensive or contracted enclosures, as may exhibit the good English farm. But to form an idea of an ornamented farm, Wooburn farm, near Weybridge, in Surrey, which brings every rural circumstance and appendage within the verge of a garden, ought to be seen.

FARRIERY, the art of shoeing horses and curing their diseases; though the word *veterinarius*, horse doctor, would be more applicable to the *veterinary art*. *See* Horse.

FARTHING, the fourth part of a penny; originally the *fourth thing*, or the fourth *in* the integer one penny.

FARQUHAR, George, an ingenious poet and dramatic writer, the son of an Irish clergyman, was born at Londonderry in 1678.

FASCIÆ, in Astronomy, certain parts on Jupiter's body resembling belts or swaths. They are more lucid than the rest of that planet, and are terminated by parallel lines, sometimes broader, and sometimes narrower.

FASCINES, in Fortification, faggots of small wood of about a foot diameter, and six feet long, bound in the middle, and at both ends.

FASCIOLA, in Zöology, the *Fluke* or *Gourd Worm*; a genus of insects of the order of vermes intestina, of which there are several species, as the hepatica, or liver fluke, which bears some resemblance to the seed of the common gourd, and is found in fresh waters, ditches, at the roots of stones, sometimes in the intestines, and often in the substance of the other viscera in quadrupeds.

FASHION Pieces, the aftmost or hindmost timbers of a ship, which terminate the breadth, and form the shape of the stern; they are united to the stern post, and to the extremity of the wing transom by a rabbet, and a number of strong nails or spikes driven from without.

FASTI, in Roman Antiquity, the calendar wherein were expressed the several days of the year, with their feasts, games, and other ceremonies.

FAT, animal oil, in its concrete substance, deposited in different parts of animal bodies. Many causes contribute to dissolve the fat in animals, as intemperature of the body, labour of mind, violent exercise, scanty diet, &c.; and rest, ease, sleep, plentiful food, generate fat. Larks and ortolans will fatten in 24 hours. *To obtain fat pure*, it must be cut in pieces, and cleaned from the interposed membranes and vessels; then cleaned from its gelatinous matter by water; afterwards melted with a little water, and kept in a fluid state till the water has entirely evaporated, which is known by the discontinuance of the boiling, for the water alone causes it to appear boiling; it is then put into clean vessels for use in pharmacy, the arts, &c.

Fat, likewise denotes an uncertain measure of capacity. Thus a fat of isinglass contains from 3½ cwt. to 4 cwt.; a fat of unbound books, four bales; of wire, from 20 to 25 cwt.; and of yarn, from 220 to 221 bundles.

FATA MORGANA, a singular aërial phenomenon, seen in the straits of Messina. When the rising sun shines from that point whence its incident ray forms an angle of about forty-five degrees on the sea of Reggio, and the bright surface of the water in the bay is not disturbed either by the wind or current, when the tide is at its height, and the waters pressed up by currents to a great elevation in the middle of the channel; the spectator being placed on an eminence with his back to the sun, and his face to the sea, the mountains of Messina rising like a wall behind it, and forming the back ground of the picture; on a sudden there appears in the water, as in a catoptric theatre, various multiplied objects; that is to say, numberless series of pilastres, arches, castles, well delineated regular columns, lofty towers, superb palaces, with balconies and windows, extended alleys of trees, delightful plains, with herds and flocks, armies of men on foot, on horseback, and many other strange images, in their natural colours, and proper actions, passing rapidly in succession along the surface of the sea, during the whole of the short period of time while the above-mentioned causes remain. All these objects, which are exhibited in the Fata Morgana, are proved by the accurate observations of the coast and town of Reggio, by P. Minasi, to be derived from objects on shore. If, in addition to the circumstances we before described, the atmosphere be highly impregnated with vapour, and dense exhalations, not previously dispersed by the action of the wind and waves, or rarefied by the sun, it then happens, that in this vapour, as in a curtain extended along the channel to the height of above forty palms, and nearly down to the sea, the observer will behold the scene of the same objects not only reflected from the surface of the sea, but likewise in the air, though not so distinctly or well defined as the former objects from the sea. Lastly, if the air be slightly hazy and opaque, and at the same time dewy and adapted to form the iris, then the above-mentioned objects will appear only at the surface of the sea, as in the first case, but all vividly coloured or fringed with red, green, blue, and other prismatic colours. As the day advances, the fairy scene gradually disappears. But the most singular instance of atmospherical refraction we ever heard of, was that described in the Philosophical Transactions, as having taken place at Hastings. The coast of Picardy, which is between forty and fifty miles distant from that of Sussex, appeared suddenly close to the English shore. The sailors and fishermen crowded down to the beach, scarcely believing their own eyes; but at length they began to recognize several of the French cliffs, and pointed out places they had been accustomed to visit. From the summit of the eastern cliff or hill, a most beautiful scene presented itself, for at one glance the spectators could see Dungeness, Dover cliffs, and the French coast, all along from Calais to St. Valleroy; and, as some affirmed, as far to the westward even as Dieppe. By the telescope, the French fishing boats were plainly seen at anchor; and the different colours of the land on the heights, with the buildings, were perfectly discernible. This refractive power of the atmosphere was probably produced by a diminution of the density of its lower stratum, in consequence of the increase of heat communicated to it by the rays of the sun, powerfully reflected from the surface of the earth. The delusion in the desert, between Alexandria and Cairo, mentioned by M. Monge, which represented villages surrounded by water, when they were, in fact, in the midst of burning sands, is attributed to the same cause.

FATHOM, a measure of six feet, used to regulate the length of the cables, rigging, &c. and to divide the lead (or sounding) lines, &c.

FEALTY, in Law, an oath taken on the admittance of a tenant to be true to the lord of whom he holds his land; but it chiefly appertains to copyhold estates held in fee and for life; and the fealty of a subject to his prince.

FEATHER, in Physiology, a general name for the covering of birds. Feathers make a considerable article of commerce, particularly those of the ostrich, heron, swan, peacock, goose, &c., for plumes, ornaments, beds, pens, &c. Geese are plucked in some parts of Great Britain five times in the year, and in cold seasons many of them die by this barbarous custom. Those feathers that are brought from Somersetshire, are esteemed the best, and those from Ireland the worst. The best method of curing feathers is to lay them in a room, exposed to the sun; and when dried, to put them in bags, and beat them well with poles to get off the dirt. Feathers, when chemically analyzed, seem to possess nearly the same properties with hair. The quill is composed chiefly of coagulated albumen, without any traces of gelatine.

FEATHER-MILL, in the salt-works, the partition in the middle of the furnace, which it divides into two chambers.

FEBRUARY is derived from *Februa*, an old Latin word, for from the very foundation of the city, we meet with Februa for purification; and *Februare*, to purge or purify. In this month the Romans held a feast in behalf of the *manes* of the deceased; and Macrobius tells us, that in this month also sacrifices were performed, and the last offices were paid to the defunct.

The Housekeeper's Kalendar for this month presents in season, *Fish:* cod, soles, sturgeons, plaice, flounders, skate, turbot, thornback, whitings, smelts, lobsters, crabs, oysters, prawns, tench, carp, perch, eels, lampreys, and crawfish.—*Meat:* Beef, mutton, veal, lamb, and pork.—*Poultry:* Turkeys, capons, pullets, fowls, chickens, pigeons, pheasants, partridges, woodcocks, snipes, hares, and rabbits.—*Vegetables:* Cabbages, savoys, coleworts, sprouts, broccoli, cardoons, beets, parsley, chervil, endive, sorrel, celery, chardbeets, lettuces, cresses, mustard, rape, radishes, turnips, tarragons, mint, burnet, tansy, thyme, savory, marjoram, radishes, cucumbers, asparagus, kidney beans, carrots, turnips, parsnips, potatoes, onions, leeks, shalots, garlic, rocambole, salsafie, skirret, scorzonera, and artichokes.—*Fruit:* Pears, apples, grapes, &c.

In the kingdoms of nature during this month, we find that bees begin to come out of their hives, sheep drop their lambs, geese begin to lay, rooks, partridges, &c. begin to pair, build their nests, and lay.

In the Kitchen Garden now sow radishes, spinage, lettuce, pease and beans, early Dutch turnips and onions for a full crop. Propagate by offsets, mint, balm, sorrel, tansy, fennel, and tarragon. Transplant onions, carrots, turnips, beet, celery, and endive. Dig and trench in moderate weather, and perform all operations *only in dry weather*.

In the hardy Fruit Department, plant all sorts of fruit-trees when the weather is fine, and strawberries. Protect roots of new-planted trees, and tops of nectarine, peach, plum, and apricot trees coming into blossom. Prune these; also fruit vines, gooseberries, currants, and raspberries. Examine your fruit room, and remove all tainted fruit.

In the culinary Hot-house Department, cucumbers, melons, salads, and potatoes, are forced—as are also kidney and French beans, and cauliflowers; the heat of all hotbeds is to be kept up by linings. Attend to the proper temperature of the pinery; and commence forcing peaches, cherries, and vines.

In the open ground Flower Garden, sow a few hardy annuals, mignonette, and ten-weeks stock. Propagate hardy plants from the root and herb. September and March are the best seasons for this work. Prepare vacant ground for trees and plants, &c.

In the Hot-house Flower Garden Department, force bulbs, prepare for annuals, border flowers, and Dutch roots,—and give air whenever the thermometer rises to 70°.

In the Pleasure Ground and Nursery Departments, plant deciduous trees and shrubs; prune, dig, sweep and roll gravel walks; lay quince, walnut, and mulberry trees. Plant ornamental shrubs and forest trees; and fell timber.

FEE, in Law, a complete feudal property; which, if *absolute*, is called a *fee-simple*; but if *limited*, a *fee-tail*. A tenant in fee-simple, is he that hath lands, tenements, or hereditaments, to hold to him and his heirs for ever, generally, absolutely, or simply; without mentioning what heirs, but referring that to his own pleasure, or to the disposition of the law. This inheritance of lands may be carved out into divers estates: as, if one grants a lease for 21 years, or for one or two lives, the fee-simple remains vested in him and his heirs; and after the determination of those years or lives, the land reverts to the granter or his heirs, who shall hold it again in fee-simple. *Limited fees* are usually clogged with conditions or qualifications of any sort.

FEE *Qualified*, is such a freehold estate as has a qualification subjoined to it, and must determine whenever the qualification is at an end.

FEE *Farm*, is when the lord, upon the creation of the tenantcy, reserves to himself either the rent for which it was before let, or a fourth part of that farm rent.

FEELERS, in Natural History, a name used by some for the horns of insects.

FEELING, one of the five external senses; the object of which is every body that has consistency or solidity enough to move the surface of our skin. It is necessary to perfect feeling, that the nerves should form small eminences, because they are more easily moved by the impression of bodies than an uniform surface. By means of this structure, we are enabled to distinguish not only the size and figure of bodies, their hardness and softness, but also their heat and cold.

FELIS, *Cat*, in Zöology, a genus of the mammalia class, belonging to the order of feræ. 1. Felis leo, the lion, an inhabitant of Asia and the interior of Africa. 2. Felis tigris, tiger, is a native of the warmer parts of Asia, and the Indian islands. 3. Felis pardus, panther, principally found in Africa, and is to that country what the tiger is to Asia, with this alleviating circumstance, that it is supposed to prefer the destruction of other animals to that of man. Felis leopardus, the leopard, is a native of Senegal and Guinea, as well as of many other parts of Africa; it also occurs in several parts of Asia. In its manners it resembles the panther. 5. Felis jubata, the hunting leopard, a native of India, where it is said to be tamed, and used for the chase of antelopes and other animals. If it misses its prey, it returns at the call of its master. 6. Felis uncia, the ounce, scarcely inferior in size to the leopard, is a native of several parts of Africa and Asia. 7. Felis onca, the Brazilian tiger, is a native of South America, and is a very fierce and destructive animal. 8. Felis pardalis, ocelot, is a ferocious animal, and inhabits the hotter parts of South America. 9. Felis puma. The puma is the largest of the American beasts of prey, and a native of many parts of America, from Canada to Brazil. 10. Felis discolor, the black tiger, is also a native of America, and is considered as a very destructive animal. 11. Felis tigrina, margay, a native of South America, is about the size of a cat. 12. Felis capensis, the Cape cat, inhabits the neighbourhood of the Cape of Good Hope, and in its manners resembles the common cat. 13. Felis manul. This species inhabits the middle part of northern Asia. It is of the size of a fox, and is of a strong and robust make. 14. Felis catus; the cat, in a state of wildness, and from which are supposed to have proceeded all the varieties of the domestic cat; it is a native of the north of Europe and Asia. The manners of the wild cat resemble those of the lynx, living in woods, and preying on young hares, birds, and a variety of other animals, which it seizes by surprise. No animal exhibits a greater degree of maternal tenderness than the cat. She even possesses a propensity to nurse with tenderness the young of a different individual. The fur of the cat yields electric sparks when rubbed: and if a clean and dry domestic cat is placed, in frosty weather, on a stool with glass feet, or insulated by any other means, and rubbed for a certain space in contact with the wire of a coated phial, it will be effectually charged by this method. 15. Felis serval. This is a native of India and Tibet, and is a very rapacious animal. 16. Felis chaus, is an inhabitant of the western side of the Caspian sea, and the Persian provinces of Ghilan and Masenderan. 17. Felis rufa, bay lynx. This species is about twice the size of a large cat, and is a native of North America. 18. Felis caracal, or Persian lynx, is a native of Asia and Africa; it is used not only in the chase of the smaller quadrupeds, but of the larger kinds of birds, such as herons, cranes, pelicans, &c. 19. Felis lynx, the common lynx, is found in all the colder regions of Europe, Asia, and America, residing in thick woods, and preying on hares, deer, birds, and other animals.

FELLING OF TIMBER. Its proper season is determined by various causes, as maturity of growth, defects in the trees, and new arrangements. Every tree that wears the picture of decay, ought to be felled, let the price and demand be what they may. But when the demand is brisk, and the price high, such as are near perfection may be cut down. In all trees there are three stages, youth, manhood, and age. The beginning of manhood is the fittest period for removing trees. All plantations, when arrived at maturity, ought to be cut down and replanted. Winter is the proper season for felling trees not to be disbarked; but summer for the resinous tribes. In spring and autumn, the wood is fullest of sap; in winter and summer least so, and is the time fittest for being levelled with the earth.

FELLOES, six pieces of wood, which, with the addition of a nave and twelve spokes, make the wheel of a gun-carriage.

FELLOWSHIP, the name of a rule in Arithmetic, useful in balancing accounts between traders, merchants, &c.; as also in the division of common land, prize-money, and other cases of a similar kind. Fellowship is of two kinds, single and double; or fellowship without time, and fellowship with time.

Single FELLOWSHIP, is when all the monies have been employed for the same time, and therefore the shares are directly as the stock of each partner. The rule in this case is as follows: As the whole stock : the whole gain or loss : : each man's particular stock : his particular share of the gain or loss. *Example.* A bankrupt is indebted to A £1000, to B £2000, to C £3000; whereas his whole effects sold but for £1200: required each man's share. Here the whole debt is £6000, therefore

$$\text{As } 6000 : 1200 :: \left\{\begin{array}{l} 1000 : \pounds 200, \text{ A's share.} \\ 2000 : \pounds 400, \text{ B's share.} \\ 3000 : \pounds 600, \text{ C's share.} \end{array}\right.$$

Double FELLOWSHIP, is when equal or different stocks are employed for different periods of time. The rule in this case is as follows: Multiply each person's stock by the time it has been engaged; then say, As the sum of the products : the whole gain or loss : : each particular product : the corresponding share of the gain or loss.—*Example.* A had in trade £50 for four months, and B £60 for five months; with which they gained £24; required each person's particular share.

$$\begin{array}{l} 50 \times 4 = 200 \\ 60 \times 5 = 300 \\ \hline \end{array}$$

$$500 : 24 :: \left\{\begin{array}{l} 200 : \pounds\ 9.\ 12s. \text{ A's gain.} \\ 300 : \pounds 14.\ \ 8s. \text{ B's gain.} \end{array}\right.$$

See Bonnycastle's "Arithmetic," and most other authors on this subject.

FELONY, in Law, means every species of crime which occasions at common law the forfeiture of lands or goods; as wilful murder, forgery, house-breaking, house-burning, horse and sheep-stealing, rape, highway-robbery, cutting and maiming, piracy, coining, and treason against the king, are punishable with death. Numerous other offences are also punishable with death; but the sentence is generally commuted into transportation for life: smaller offences involve transportation for fourteen or seven years; and petty ones are punished by imprisonment, whipping, pillory, burning in the hand, or by fines. The idea of felony is, indeed, so generally connected with that of capital punishment that we find it difficult to separate them; and to this usage the interpretations of the law do now conform. And, therefore, if a statute makes any *new offence felony*, the law implies that it shall be punished with death, by hanging, as well as with forfeiture; unless the offender prays the *benefit of clergy*, which all felons are entitled once to have, unless the same is expressly taken away by statute. And the *benefit of clergy* means a privilege formerly allowed, by virtue of which a man convicted of felony, or manslaughter, was put to read in a *Latin Book*, of a Gothic black character (or old English), and if the Ordinary of Newgate said *Legit ut Clericus*, *i. e.* "He reads like a clerk"—or parson—the felon was only burned in the hand, and set free, otherwise he suffered death for his crime.

FELSPAR, is a hard kind of stone which varies much in colour, being flesh red, bluish gray, yellowish white, milk white, or brownish yellow. It is found in mass, disseminated or crystallized in four, six, and ten-sided prisms; will strike fire with steel, and is sometimes opaque and coloured, sometimes transparent and whitish. The name is derived from the German language, and signifies spar of the fields. It is a very common substance, and constitutes a principal part of many of the highest mountains of the world. When exposed to weather, it gradually acquires an earthy appearance, and at length passes into porcelain clay. Felspar is of great use in the manufacture of the finer earthenwares. Of the two substances which chiefly compose the porcelain of China, one called *petunzé* is a whitish laminar kind of felspar, and the other, called *kaolin*, very nearly resembles the common species in its decomposed state. This mineral is used in the celebrated porcelain manufactured at Seves, near Paris, for the purpose of giving to it a white and transparent appearance. Previously to being used, it is pulverized, made into a paste, and suffered to dry. It is sometimes applied to the surface of ornamental vases in the form of enamel.

Labrador FELSPAR, is a very beautiful stone of smoky gray colour, intermingled with veins and shades of blue, green, and golden yellow, exhibiting a brilliant play of colours, according to the position with respect to the light in which the stone is held. The original discovery of this singular mineral was by the Moravian missionaries, on the island of St. Paul, near the coast of Labrador; but it has since been found in various parts of Norway and Siberia. In the late Leverian museum there was exhibited a remarkably fine mass of Labrador felspar, the surface of which was polished, and exhibited some of the most splendid and beautiful colours that could be imagined. It was considered to have been the most capital specimen that was ever brought to England. This mineral, on account of its hardness, its brilliancy, and its capability of receiving a high polish, is in considerable estimation among lapidaries for different kinds of ornamental work, particularly for the tops and bottoms of snuff-boxes, for brooches, and necklaces.

FELTING, the method of working up hair or wool into a species of cloth, independently of either spinning or weaving. *See* HAT-MAKING.

FELUCCA, a little vessel with oars, frequent in the Mediterranean.

FEMINEUS, *Flos*, a female flower. By this name Linnæus denominates a flower which is furnished with the pistillum. Female flowers may be produced apart from the male, either on the same root, or on distinct plants. The birch and mulberry are examples of the first case; willow and poplar of the second.

FEMME COVERT, in Law, a married woman; as *femme sole* is an unmarried woman, whose debts contracted before marriage, become those of her husband after it.

FEN, a place overflowed with water, or abounding with bogs, as the *bogs* in Ireland, the *fens* in Lincolnshire, Kent, and Cambridgeshire. These fens abound in duck, teal, mallards, pike, eels, &c.; and a herbage that is very nourishing to sheep and cattle.

FENCE, in Gardening and Husbandry, a hedge, wall, or ditch, &c., or other enclosure made round gardens, fields, woods, &c. Fences round parks are generally of paling, which, if well made of winter-fallen oak, will last 40 years. But a principal thing to be observed, is, not to have such fences too heavy, as their own weight will cause them to decay. The posts should not be more than 9 feet asunder, the rails triangular, the pales cleft, ¾ inch one edge and ¼ the other; and every alternate pale 9 inches above the intermediate one.

FENCING, an accomplishment both agreeable and useful—*agreeable*, as it is a noble and innocent amusement; *useful*, as it forms the body, and furnishes its practitioners with a most manly method of self-defence, whether in support of their honour, or to protect life, when attacked by those turbulent and dangerous bullies, whose chastisement is of service to society in general.

FEODAL, Feud, or Fee *System*, called also "the *Feudal System*," which existed in Europe, in time back, was this:—When the northern nations, the Goths, Vandals, &c. overran the Roman empire in the 5th century of our æra, they brought the feudal system along with them, and established it wherever they settled. According to this system, the victorious general allotted considerable tracts of land to his principal officers; while they, in like manner, divided their possessions among the inferior officers, and such of the common soldiers as were bravest in battle. This stipend of land they called a *fief*, *feod*, or *feud;* and the condition of tenure was, that the *tenants in fief* should serve the owner of the fee-simple, or lessor, or lord, at home and abroad in all wars and military expeditions. To this they bound themselves by *an oath of fealty*, so that a reciprocal tie linked the highest chief with the humblest of his followers, who could not only enjoy but dispose of their territory as they pleased, the possessor being, by his occupancy, bound for military service, as was his predecessor. When William the Conqueror was crowned king of England, he secured his victory by loading the Saxons with the heaviest chains of the feudal laws, and imposed upon all the proprietors of land, various bardships unknown before in England. These were the subjects of complaint and opposition for many ages after the conquest. With the Norman *language*, which was adopted in the courts of justice, were introduced the Norman *laws*. The ancient trial by *jury* was superseded by the uncertain and unjust decision by *single combat*, a practice which was established by law, and conducted with regular ceremonies and forms of devotion. The extinction of all fires at the melancholy sound of the *curfew* or evening bell, was a striking emblem of the extinction of liberty. The nation groaned under every distress that a politic and obdurate conqueror could inflict; and their chains were so firmly riveted, as to require a degree of energy and unanimity to break them, which the oppressed Saxons had not sufficient resolution to exert. The Conqueror not only broke the line of hereditary succession to the crown of England, but reduced the people to the most abject slavery. The confiscation of the estates of the Saxon nobles indicated both his policy and rapacity. He caused a survey to be made of all the lands in the kingdom, with a distinct account of their extent and value, and the names of the proprietors. This curious record, called Doomsday Book, *Domus Dei Liber*, is preserved in the Exchequer, and has been printed. These lands were divided into 60,215 military fiefs; some were reserved by the Conqueror for himself; and the rest were bestowed upon his Norman followers, to be held under the obligation of each vassal taking up arms, and appearing in the field, whenever the king raised his standard of war.

FEOFFMENT, in Law, the gift of any corporeal hereditament to another. He that so gives or enfeoffs, is called the feoffor, and the person enfeoffed, or put in possession, is denominated the feoffee.

FERÆ, in Zöology, an order of quadrupeds, the distinguishing characters of which are, that all the animals belonging to it have fore-teeth conic, usually six in each jaw; tusks longer; grinders with conical protections; feet with claws; claws subulate; food carcasses, and preying on other animals.

Feræ *Naturæ*, are animals of a wild nature, in which a man has only a qualified and limited property, which sometimes subsists, and at other times does not.

FER DE FOURCHETTE, in Heraldry, a cross having at each end a forked iron, like that formerly used by soldiers to rest their muskets on. And *Fer de Moulin*, is a bearing supposed to represent the iron ink, or ink of a mill, which sustains the moving millstone.

FERGUSON, James, an eminent experimental philosopher and mechanic, was born of very poor parents, in Bamffshire, in Scotland, in 1710; in which humble situation he very early gave great proofs of an original and enterprising genius, which he afterwards displayed much to his own credit and emolument; having accumulated at his death, which happened in 1776, a sum of £6000. Mr. Ferguson was fellow of the Royal Society, and author of some works on astronomy and mechanics.

FERMAT, Peter, a celebrated French mathematician, was born in 1590, and became, by his talents and acquirements, counsellor of the parliament of Toulouse. Fermat was intimately acquainted with all the first-rate mathematicians of his age, either personally or by correspondence.

FERMENTATION, an intestine motion, excited by the assistance of proper heat and fluidity between the integrant and constituent parts of farinaceous, saccharine, and a few other substances, from which new combinations of their respective principles result. The various kinds of fermentation are—1. The Vinous; 2. The Acetous; 3. The Panary; 4. The Putrid.

1. *The Vinous Fermentation.*—When a solution of saccharine matter, or saccharine matter and starch, or sweet juices of fruits, suffer this change, the result is beer or wine, and the process is called a vinous fermentation.

2. *Acetous Fermentation.*—When wine, or any fermented or vinous liquor, is exposed to a heat, from 75° to 80° Fahrenheit, and access of air is permitted, the fluid becomes torpid, a new change of principles takes place; it loses its taste and smell, becomes sour, and is converted into vinegar.

3. *Panary Fermentation.*—This is the fermentation produced by the action of yeast or flour and water in the making of bread.

4. *Putrid Fermentation.*—This is the last change or final decomposition of vegetables. Without moisture, heat, and a due access of air, this decomposition does not take place. In this state of fermentation, ammonia is thrown out, accompanied by a very offensive smell. Vegetables which contain albuminous matter and gluten, are most liable to putrefaction or fermentation.

FERRAGO, simply rust, called in Chemistry *oxide* of iron; from *ferrum*, iron.

FERRETTO, in Glass Making, a substance used in colouring glass, and obtained from a simple calcination of copper and powdered brimstone, or copper and white vitriol. *See* Glass Making.

FERRUGINOUS, any thing partaking of iron, or that contains particles of that metal.

FERRY, a liberty by prescription, or by the king's grant, to have a boat for passage on a frith or river, for carrying passengers, horses, or any goods, over the same for a reasonable toll or tax.

FERTILITY, as of soils, &c. denominates their being fruitful, prolific, &c. In all animals, every thing that promotes health conduces to fertility; and perfect fecundity must result from good blood, good spirits, high health, and perfect animal functions. All the medicines, nostrums, and specifics, different from these, are arrant quackery. Such is the doctrine of physiologists; yet we see most fertile the wives of the labouring poor—of mechanics, who earn perhaps only 18 shillings a week, on which a family of seven persons has to be supported. This is incontrovertible. It is obvious then, that high living is not necessary to the fecundity of our species, though it is also a fact that there are living, at this time (1825), mothers of ten, nay, sixteen children, who have all their lives lived in the lap of luxury. As respects the fertility of the mother earth, *soils* may be improved by *pulverization*, which allows the rain to penetrate the soil, and gives scope to the roots of vegetables, according to their abundance. It besides increases the capillary attraction, which is always greater in proportion as the particles of earth are finely divided. Air, light, and heat, are also communicated to under strata, by turning up and laying open the soil; and plants and vegetables cannot flourish in all their perfection without those great elements of animating nature. Ploughing, digging, harrowing, raking, dunging, scattering of ashes, and alkali residues, are the great agents in mixing, enriching, warming, and nourishing soils, so as to give them all that fertility of which they are capable; and where these important matters are well regulated, fertility will ordinarily take place, and the desire of the owners or occupiers of the land will ensue.

FESSE, in Heraldry, one of the nine honourable ordinaries. *Fesse point* is the exact centre of the escutcheon; *fesse ways* denotes any thing borne after the manner of a fesse, *i. e.* in a rank across the middle of the shield; and *fesse per fesse* implies a parting across the middle of the shield from side to side, through the fesse point.

FESTOON, in Architecture, &c. an ornament in form of a garland of flowers, fruits, and leaves, intermixed or twisted together, and generally more bulky in the middle than towards the ends, which hang down perpendicularly, as in the annexed figure.

FEU Duty, in Scots Law, the annual duty which a vassal, by the tenor of his right, becomes bound to pay his superior; hence the tenure of *few holding*.

FEVER, a disease in which the body is violently heated, the pulse quickened, and the patient attacked alternately with heat and cold. Fevers are either intermittent, continued, remittent, scarlet, &c. and usually attended with headache, thirst, giddiness, and sometimes difficulty of breathing. Their treatment is as various as their names, and the systems of practitioners. But we cannot enter upon this topic, which is of too much consequence to be handled in a few pages.

FIBRE, in Anatomy, a simple body, being fine and slender like a thread, and serving to form other parts. Hence fibrin is that substance which constitutes the fibrous part of the muscles of animals.

FIBRIN, is a peculiar organic compound found in vegetables and in animals. There are few vegetables from which this substance is obtained distinctly characterized, but it is found abundantly in all animals. Chyle, the blood, and the muscular flesh, produce it. If the blood from the veins be beaten with rods, long reddish filaments of fibrin will adhere to them, and if washed in cold water, they will become colourless, and the matter of fibrin will be found to be solid, white, insipid, without colour and smell. When moist, it is, in some degree, elastic; when dried, it is yellow, hard, and brittle. By distillation it yields carbonate of ammonia, some acetate, brown oil, and gaseous products. There remains in the retort a charcoal, which, after combustion, leaves phosphate of lime, phosphate of magnesia, with carbonate of lime and soda.

FIBROLETE, a mineral, first observed by Bournon, in the matrix of the imperfect corundum. It is composed of 58.25 alumina, 38.00 silica, 3.75 a trace of iron, and loss.

FICUS, a genus of the triœcia order, in the polygamia class of plants, and in the natural method ranking under the 53d order, scabridæ. There are 56 species, of which the banian-tree is the most remarkable. *See* Banian-tree.

FIDD, on board ship, is an iron or wooden pin, to splice and fasten ropes together.

FIELD, in Heraldry, the whole surface of the shield, or the continent, so called because it containeth those achievements anciently acquired in the field of battle. It is now the ground on which the colours, bearings, metals, furs, charges, &c. are represented.

Field *Book*, in Surveying, the angles, stations, distances, &c. are set down. *See* Surveying *of Land*.

Field *Pieces*, small cannons from 3 to 12 pounders, carried along with an army; and the *Field Staff*, carried by the gunners, is about the length of a halbert, with a spear at one end, having on each side ears screwed on, like the cock of a matchlock, into which the bomadiers screw lighted matches when they are upon command; and then the field staffs are said to be armed.

Field *Works*, in Fortification, are those thrown up by an army in besieging a fortress, or by the besieged to defend the place; as the fortifications of camps, highways, &c.

FIERI FACIAS, a judicial writ that lies at all times within the year and day for him who has recovered in an action of debt or damages, to the sheriff, to command him to levy the debt or damages of his goods against whom the recovery was had.

FIFE, a wind instrument of the martial kind, consisting of a short narrow tube with holes disposed along the side, for the regulation of its tones.

FIFTH, in Music, a distance comprising four diatonic intervals, *i. e.* three tones and a half. *Fifth Sharp*, is an interval consisting of eight semitones.

FIFTEENTH, an ancient tribute or tax laid upon cities, boroughs, &c., through all England, and so termed, because it amounted to a fifteenth part of what each city or town had been valued at; or it was a fifteenth of every man's personal estate, according to a reasonable valuation. In doomsday-book, there are certain rates mentioned for levying this tribute yearly; but since, any such tax cannot be levied but by parliament.

FIGURE, in Grammar, is a deviation from the natural rules of etymology, syntax, and prosody, either for brevity, elegance, or harmony.

Figure, in Rhetoric, is a manner of speaking different from the ordinary and plain mode, and more emphatical, expressing a passion, or containing a beauty.

Figure *of a Body*, in Geometry and Mensuration, denotes generally its form or shape; whence as all bodies are of some form or figure, figurability is reckoned amongst the essential properties of body or matter. A body without figure would be without limits, and must therefore be infinite.

Figure, in Painting and Designing, denotes the lines and colours which form the representation of any animal, but more particularly of a human person. *See* Drawing.

Figures, in Arithmetic, are the nine digits, 1, 2, 3, 4, &c.

FILACER, or **Filazer**, an officer of the court of common pleas, so called, because he files those writs whereupon he makes out process. There are fourteen of them in their several divisions and counties, and they make out all writs, and processes upon original writs, issuing out of chancery.

FILAMENT, in Anatomy and Natural History, &c. is the same as *fibre*, and is applied to those fine threads that compose the flesh, nerves, skin, plants, roots, &c. of all vegetating organized bodies. Hence the thread, cloth, &c. from flax, nettles, hop stalks, &c.

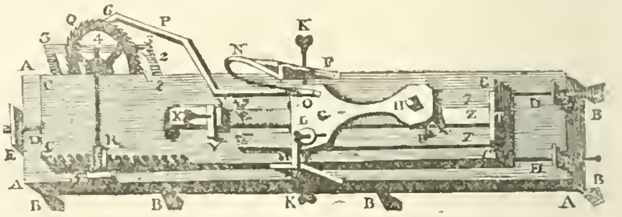
Filaments, *Vegetable*, form a substance of great use in the arts and manufactures; furnishing thread, cloth, cordage, &c., as the filamentous parts of hemp and flax are employed among us.

FILARIA, a genus of insects of the order intestina. There are several species, infesting different animals and insects. The medinensis is the most remarkable species; it inhabits the Indies, and is frequent in the morning dew, whence it enters the feet of the slaves, and creates the most troublesome itchings, accompanied with inflammation and fever.

FILE, among Mechanics, a furrowed tool used to polish or prepare metals, &c. and usually cut in steel.

Mr. Nicholson has obtained a patent for machinery for the manufacture of files; which consists, 1. Of a carriage, in which the file is fixed, and moved for the purpose of receiving the strokes of a cutter or chisel. 2. The anvil by which the file is supported beneath the part which receives the stroke. 3. The regulating gear, by which the distance between the strokes is governed: and 4. The apparatus for giving the stroke or cut. Those four parts are supported by a frame of wood or metal, according to the nature of the work to be performed. By this machinery, a blind man can cut a file with more exactness than the most skilful workman in the ordinary way.

FILES, Machines for Cutting of. There have been various contrivances for this purpose, but among the best we are acquainted with, is one described in the Transactions of the American Philosophical Society. A A A A, (as in the following figure,) is a bench made of well-seasoned oak, the face of which is planed very smooth. B B B B B, the feet of the bench, which should be substantial. C C C C, the carriage on which the files are laid, which moves along the face of the bench A A A A, parallel to its sides, and carries the files gradually under the edge of the cutter or chisel H H, while the teeth are cut: this carriage is made to move by a contrivance somewhat



similar to that which carries the log against the saw of a saw-mill, as will be more particularly described. D D D, are three iron rods inserted in the ends of the carriage C C C C, and passing through holes in the studs E E E, which are screwed firmly against the ends of the bench A A A A, for directing the course of the carriage C C C C, parallel to the sides of the said bench. F F, two upright pillars, mortised firmly into the bench A A A A, nearly equidistant from each end of it, near the edge, and directly opposite to each other. G, the lever or arm which carries the cutter H H, (fixed by the screw I,) and works on the centres of two screws K K, which are fixed into the two pillars F F, in a direction right across the bench A A A A. By tightening or loosening these screws, the arm which carries the chisel may be made to work more or less steadily, L is the regulating screw, by means of which the files may be made coarser or finer; this screw works in a stud, M, which is screwed firmly upon the top of the stud F: the lower end of the screw L bears against the upper part of the arm C, and limits the height to which it can rise. N is a steel spring, one end of which is screwed to the other pillar F, and the other end presses against the pillar O, which is fixed upon the arm G; by its pressure it forces the said arm upwards, until it meets with the regulating screw, L. P is an arm with a claw at one end marked 6, the other end is fixed by a joint into the end of the stud or pillar O; and by the motion of the arm G, is made to move the ratch-wheel Q. This ratch-wheel is fixed upon an axis, which carries a small trundle-head or pinion R, on the opposite end; this takes into a piece S S, which is indented with teeth, and screwed firmly against one side of the carriage C C C C: by means of this piece motion is communicated to the carriage. T is a clamp for fastening one end of the file Z Z, in the place or bed on which it is to be cut. V is another clamp or dog, at the opposite end, which works by a joint W, firmly fixed into the carriage C C C C, Y is a bridge, likewise screwed into the carriage, through which the screw X passes, and presses with its lower end against the upper side of the clamp V; under which clamp the other end of the file Z Z, is placed, and held firmly in its situation while it is cutting, by the pressure of the said clamp V. 7 7 7 7 is a bed of lead, which is let into a cavity formed in the body of the carriage, something broader and longer than the largest fixed files; the upper face of this bed of lead is formed variously, so as to fit the different kind of files which may be required. At the figures 2 2, are two catches which take into the teeth of the ratch-wheel Q, to prevent a recoil of its motion. 3 3 is a bridge to support one end 4, of the axis of the ratch-wheel Q. 5, a stud to support the other end of the axis of that wheel.

When the file or files are laid in their place, the machine must be regulated to cut them of the due degree of fineness, by means of the regulating screw L; which, by screwing further through the arm M, will make the files finer, and *vice versa*, by unscrewing it a little, will make them coarser; for the arm G will by that means have liberty to rise the higher, which will occasion the arm P, with the claw, to move further along the periphery of the ratch-wheel, and consequently communicate a more extensive motion to the carriage C C C C, and make the files coarser. When the machine is thus adjusted, by striking with a hammer on the head of the cutter or chisel H H, all the movements are set to work, and by repeating the stroke with the hammer, the files on one side will eventually be cut. They must then be turned, and the operation repeated for cutting the other side. This machine may be made to work by water as well as by hand, to cut large or small, coarse or fine; or indeed any number at the same time. The materials and dimensions of this machine must be left to the judgment of the mechanic, but the whole must be capable of bearing a considerable portion of violence and thumping.

FILLAGREE WORK, a kind of enrichment on gold or silver, wrought delicately like threads or grains, or both intermixed. The gold and silver *fillagree* of Sumatra is the most esteemed of the world, yet is it made with the coarsest tools,—a piece of bamboo cane serving as a blow-pipe, a couple of old nails as a pair of compasses: an old iron hoop serves many purposes. The price of the workmanship depends on the difficulty or uncommonness of the pattern, but, in general, it is only one-third of the value of the metal, except in matters of fancy, when it amounts to as much as the gold.

FILLET, in Architecture, a little square member used in divers places, but generally as a sort of corona over a greater moulding. In Heraldry, a bordure or orle, one-third part the breadth of the common bordure. It runs quite round, near the edge, as a lace over a cloak. It sometimes appears like a scarf across the shield.

FILLETS, in the Manege, the loins of a horse which begin at the place where the hinder part of the saddle rests.

FILTER, or FILTRE, in Chemistry, a strainer through which any fluid is passed, to separate the gross particles, and render it limpid.

FILTERING BASONS, &c., are either natural or artificial, for the purpose of purifying water. Natural filters are found in rocks, mountains, beds of sand, gravel, &c. Artificial filtering basons consist of equal parts of pipe-clay and coarse sand. They should be three-quarters of an inch thick.

FILTRATION, in Chemistry, is sifting through the pores of paper, flannel, or fine linen or sand, pounded glass, or porous stones, and the like; but it is used only for separating fluids from solids, or particles that may happen to be suspended in them, and not chemically combined with the fluids.

FIN, in Natural History, a well known part of fishes, consisting of a membrane supported by rays, or little bony or cartilaginous ossicles.

FINANCE, the economy of the public revenue and expenditure of nations. The English system of finance rests on the produce of the various taxes, the aggregate amount of which, after deducting the expenses of collecting, together with a few small articles which cannot properly be called taxes, forms the whole of the public income.

FINE, in Law, has different significations. It sometimes denotes a formal conveyance of lands or tenements, or of any inheritable thing, in order to cut off all controversies: sometimes it means a sum of money paid for entering into the possession of lands or tenements let by lease. Again, it signifies a pecuniary mulct for an offence conducted against the king, or the lord of the manor.

FINERS of gold and silver, are those who separate these metals from coarser ores.

FIRE, that invisible fluid by which bodies are expanded, and become hot, is best known from its effects; and to these, and not to the disputes that have agitated philosophers concerning this subject, must we look for all the knowledge to be gained respecting this chief agent in nature, on which animal and vegetable existence have so close and inscrutable a dependence, and without which it does not appear that nature could exist a single moment. Whenever you perceive a number of qualities always existing together, you are warranted to conclude, that there is some substance which produces those qualities. Fire drives out other bodies from any given space; it has a constant tendency to diffuse itself uniformly, so as to maintain an equilibrium; it dilates some substances; it must have penetrated them; it expels other bodies, and takes their place; therefore we conclude, it must itself be a body—*a real and material substance.*

Air is a *substance*, and not a *quality*. People who are unacquainted with the principles of natural philosophy, would not suppose that the air by which we are surrounded is a material substance, like water, or any other visible matter. Being perfectly invisible, and affording no resistance to the touch, it must seem to them extraordinary to consider it as a solid and material substance; and yet a few simple experiments will convince any one that it is really matter, and possesses weight, and the power of resisting other bodies that press against it. And it differs from all other fluids in the four following particulars:—

1 It can be compressed into a much less space than what it naturally possesses. 2. It cannot be congealed, or fixed, as any other fluids may. 3. It is of a different density in every part upward from the earth's surface, decreasing in its weight, bulk for bulk, the higher it rises. 4. It is of an elastic, or springy nature, and the force of its spring is equal to its weight.

Fire, in common with air, is subject to these laws. Light is an emanation of fire; the decomposition of the rays of light proves its materiality; what is light on the surface of a burning glass, is fire at its focus; whatever, therefore, proves the materiality of light, is applicable to fire.

We conclude, therefore, that fire is a real and material substance; and by the word fire we mean that very subtile fluid which all men call fire; heat is an *effect* of fire, or a proof of its presence; *absolute heat* and fire are words of the same import; *relative heat* is an epithet applied to the measured effects of fire. Fire penetrates all bodies, even the hardest; and one of its most constant characters is a continual tendency to equilibrium, or to flow from a warmer to a colder substance.

Heat, considered as a sensation, or, in other words, sensible heat, is only the effect produced upon our organs by the motion of *caloric*, disengaged from the surrounding bodies. In general we receive impressions only in consequence of motion, and it might be established as an axiom, that *without motion there is no sensation.* This general principle applies very accurately to the sensations of heat and cold. When we touch a cold body, the caloric, which always tends to become in equilibrio in all bodies, passes from our hand into the body we touch, which gives us the feeling or sensation of cold. The contrary happens when we touch a warm body; the caloric then, in passing from the body into our hand, produces the sensation of heat. If the hand and the body touched, be of the same temperature, or very nearly so, we receive no impression either of heat or cold, because there is no motion or passage of caloric. *See* CALORIC, EVAPORATION, HEAT, PYROMETER.

FIRE *Arrow*, a steel or iron dart used by privateers and pirates, to set fire to the sails of the enemy in battle.

FIRE, *Balls of*, in Meteorology, a kind of luminous bodies, generally appearing at a great height above the earth, with a splendour surpassing that of the moon; and sometimes equaling her apparent size. They generally proceed in this hemisphere from north to south with vast velocity, frequently breaking into several smaller ones, sometimes vanishing with a report, sometimes not.

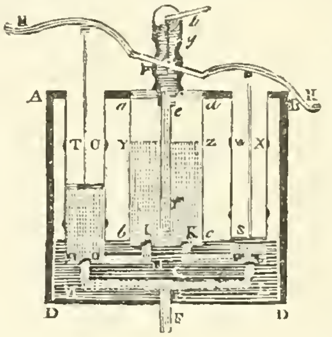
FIRE *Ball*, in the art of War, a composition of meal-powder, sulphur, saltpetre, pitch, &c., about the bigness of a hand-grenade, coated over with flax, and primed with a slow composition of a fusee. This is to be thrown into the enemy's works in the night-time, to discover where they are: or to fire houses, galleries, or blinds of the besiegers; but they are then armed with spikes, or hooks of iron, that they may not roll off, but stick or hang where they are designed to have any effect.

FIRE *Barrels*, used in fire-ships, and ought to be of a cylindrical form, as best adapted to contain the reeds with which they are filled, and more convenient for stowing them between the troughs in the fire-room. Their inside diameters should not be less than 21 inches, and 30 inches are sufficient for their length. The bottom parts are first well stowed with short double-dipped reeds placed upright, and the remaining vacancy is filled with fire-brand composition, well mixed and melted, and then poured over them. The composition used for this purpose is a mass of sulphur, pitch, tar, and tallow. There are five holes of 3-4 inch in diameter, and three inches deep, formed in the top of the composition while it is yet warm; one being in the centre, and the other four at equal distances round the sides of the barrel. When the composition is cold and hard, the barrel is primed by filling those holes with fuze composition, which is firmly driven into them so as to leave a little vacancy at the top to admit a strand of quick-match twice doubled. The centre hole contains two strands at their whole length, and every strand must be driven home with mealed powder. The loose ends of the quick-match being then laid within the barrel, the whole is covered with a dipped curtain, fastened on with a hoop that slips over the head of the barrel to which it is nailed. The barrels should be made very strong, not only to support the weight of the composition before firing, when they are moved or carried from place to place, but to keep them together whilst burning: for if the staves are too light and thin, so as to burn very soon, the remaining composition will tumble out and be dissipated, and the intention of the barrels to carry the flame aloft, will accordingly be frustrated. The curtain is a piece of canvass, nearly a yard in breadth and length, thickened with melted composition, and covered with saw-dust on both sides.

FIRE *in Chimneys, method of Extinguishing.* It is well known, that the inner parts of chimneys easily take fire; the soot that kindles therein, emits a greater flame, according as the funnel is more elevated, because the current of air feeds the fire. If this current could therefore be suppressed, the fire would soon be extinguished. The surest and readiest method is, to apply a wet blanket to the throat of the chimney, or over the whole front of the fire-place. If there happens to be a chimney-board, or a register, apply the same immediately; and having, by that means, stopped the draught of air from below, the burning soot will be put out as completely as a candle is put out by an extinguisher, which acts exactly upon the same principle.

FIRE *Cocks.* The churchwardens in London, and within the bills of mortality, are to fix fire cocks at proper distances in streets, and keep a large engine and hand-engine for extinguishing fire, under a penalty of £10. stat. 6. Ann. c. 31.

FIRE *Engine*, is the name commonly given to a machine, by which water is thrown upon fires in order to extinguish them. Various machines have, at different times, been contrived for this purpose; but the most essential particulars in a few of them we can only here describe. The usual construction of the fire-engine, after the improvements were made in it by Newsham, was nearly that which is exhibited in the annexed figure, and which represents a vertical section of the engine, which is in fact but two forcing pumps communicating with a large air vessel. The motion of the water is effected by the pressure of the atmosphere, the force of men acting upon the extremities H′, H″, of a lever, and thence giving motion to the pistons S and R, and by the elasticity of condensed air, in the following manner:—When the piston R is raised, a vacuum would be made in the barrel T U, if the water did not follow the piston R, from the inferior canal E M, (through the valve H,) which rises through the tube E F, immersed in the water of a vessel by the pressure of the atmosphere on its surface. The water of the barrel T U, by the succeeding depression of the piston R, shuts the valve H, and is forced, through the superior canal O N, to enter by the valve I, into the air-vessel *a b c d;* and the like being done alternately by the other barrel W X, and its piston S, the air-vessel is, by these means, continually filling with water, which compresses the air on the surface of the water in that vessel, and proportionally augments its spring; which at length is so far increased as to re-act with great force on the surface Y Z of the subjacent water, and compel it to ascend through the small tube *e f* to the stop-cock *p g*, where upon turning the cock *p* the water is suffered to pass through a pipe *h* fixed to a ball and socket; from the orifice of which it issues with a great velocity, in a continued stream, to a considerable height or distance; and it is usually kept from diverging too soon in its progress by means of a long series of flexible leather pipes, properly joined together, and known among the firemen by the name of the *hose.*



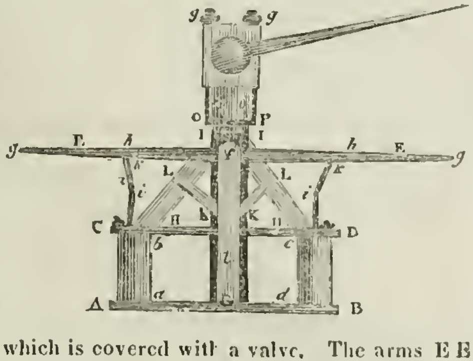
Newsham contrived his engines in such a manner, that part of the men who work them exert their force by treading, which is more effectual than any other way that men can work at such engines; the whole weight of the body being sufficiently thrown on the forces of the pumps; and even part of a man's strength may be added to the weight by means of horizontal pieces, to which he can apply his hands when he is treading; whereas, by applying the hands to move levers or turn winches, the power must act very unequally. This is the reason why with the same number of men he has generally thrown water further, higher, and in greater quantities, with the same sized engines, than other engineers who have tried their engines against his. Yet the combination of human weight and strength here recommended has rarely been practised in any subsequent fire-engines, or indeed in any machines whatever, except the ingenious walking crane of Hardie.

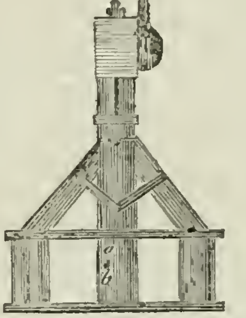
The chief artifice in the engine according to the construction just described, is the contrivance to produce a *continual stream*, which is done by the compression and proportional elasticity of air in the barrel *a b c d*, called the air-vessel. For the air, being an elastic fluid, will be susceptible of compression in any degree by the water forced in through the valves at I, K; and since the force of the air's spring will always be inversely as the space it possesses, it follows that when the air-vessel is half full of water, the air will be compressed into half the space it possessed at first, and therefore its spring will be twice as great as at first. But this spring at first was equal to the pressure of the atmosphere on the same surface; for if it were not, it could not have sustained or resisted the pressure of the atmosphere which stood over it, and consequently could not have filled the vessel before the water was driven in, which yet we find it did, and maintained an equilibrium with the common air. The vessel then being half filled with water, or the air compressed into half the first space, its spring will in this case be equal to twice the pressure of the atmosphere; and therefore when the stop-cock at *p* is turned, the air within, pressing on the subjacent water with twice the force it meets with from the external air in the pipe *c f*, will cause the water to spout out of the engine to the height of 32 or 33 feet, if the friction is not too great.

When the air-vessel is two-thirds full of water, the air takes up one-third part, whence its spring will be three times as great as that of the common air, and it will project the water with twice the common atmospheric pressure, consequently it will rise to the height of 62 or 64 feet. When the air-vessel is three-fourths full of water, the air will be compressed into its one-fourth part, and so will protrude the water with three times the atmospheric pressure, and carry it to the height of 96 or 99 feet.—*Dr. Gregory's Mech.*

Various alterations and improvements have been made from time to time in the construction of fire-engines, by Bramah, Dickenson, Simpkin, Rowntree, and Phillips, who have secured their inventions from infringement by patents. Of Furst's engine for extinguishing fires, the following is a short description:—From a platform rises an upright pole or mast, of such height as may be judged necessary; a gaft slides upon it in an ascending direction, and along both is conveyed the leather hose from the engine. The branch or nose-pipe of the engine projects at the extremity of the gaft; towards which an iron frame is fixed, whence two chains are suspended; and from these hang ropes, which serve to give an horizontal direction to the branch; while other ropes, that run through proper pulleys, and are thus conveyed down the mast, serve likewise to communicate a vertical motion to it. By these means, the branch or nose-pipe of the engine is conducted into the window of any room where the fire more immediately rages; and the effect of the water discharged is applied in the most efficacious manner to the extinguishing of the flames.

A cheap and simple fire-engine is that invented in America by Ben. Dearborn, of which the following are the particulars: A B and C D, in the figure, are the edges of two planks, confined by 4 bolts; *a b* and *c d* are two cylindrical barrels, in each of which a piston, with a valve, is fastened to the spear *e*, and is moved up and down alternately by the motion of the arms E E. Beneath each barrel a hole is made through the plank A B, which is covered with a valve. The arms E E are suspended on the common centre *f*; there are also arms parallel to these on the opposite side; *g g* are the ends of handles which are fastened across the ends of the arms. At *h* a bolt goes across from arm to arm, to which the piece *i k* is affixed, and on which it plays: the lower end of this piece is fastened to the top of the spear *e*. G *l f* is a standard for the purpose of supporting the arms, to which there is a correspondent one on the opposite side; both are notched into the edges of the planks, where they are secured by a bolt, which passes through them at *l*, and has a nut or fore-lock on the opposite side. H I, H I, are square braces, answering the purpose of ducts, through which the water ascends from the barrels, passing through the plank at *m*. K L, K L, are irons in the form of a staple, in order to confine the braces: the lower ends of these irons meet, and are secured by a bolt passing through them, and M N *n o*, which is a piece that goes up through a mortise in the centre of the planks. This piece is square from the lower end, till it reaches the top of the braces, whence they become cylindrical to the top, the upper end being perforated sufficiently low down, in order to communicate with the braces. O P is an iron ring that surrounds the tube, and has two shanks which ascend through the head, which screws on the top at *p q*; *r s* is a ferule nailed round the tube.



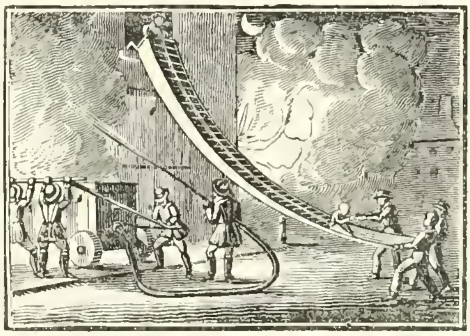


The annexed figure is the same engine; the arms and standards being taken off, in order to delineate more clearly the mode of securing the braces; an object which is completely effected by a wedge driven into the mortise *a*; beneath the upper plank *b* is a hole for admitting a passage to the bolt, which secures the standards. In this figure a side view of the head is given, with the pipe in a perpendicular direction. The machine is confined within a box, set on wheels, as in the common fire-engines. The whole is made of wood, excepting the spears of the pumps, and a few bolts, &c. The advantages of this machine are, that it can be made in any place where common pumps are manufactured; that the interior work will not exceed one-fourth of the price of those which are constructed on the usual plan; and that they are incomparably more easy to work than the common ones; circumstances which strongly recommend the American fire-engine to the attention of the public.—*Gregory's Mechan.*

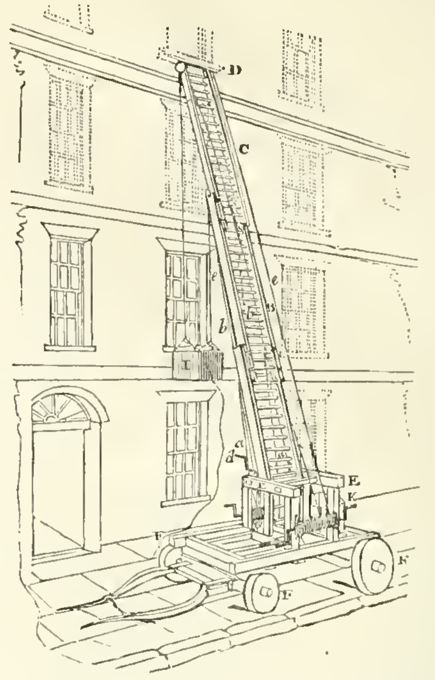
FIRE-*Escape*, a machine for removing persons from the upper stories of houses on fire, consists of a pole, a rope, and a basket. The pole is of fir, or a common scaffold pole, of any convenient length, from 36 to 46 feet. The diameter at bottom, or greatest end, about five inches; and at the top, or smallest end, about three inches. At three feet from the top is a mortise through the pole, and a pulley fixed to it of nearly the same diameter with the pole in that part. The rope is about three-quarters of an inch diameter, and twice the length of the pole, with a spring-hook at one end, to pass through the ring in the handle of the basket when used: it is put through the mortise over the pulley, and then drawn tight on each side to near the bottom of the pole, and made fast there till wanted. The basket should be of strong wicker-work, three feet and a half long, two feet and a half wide, rounded off at the corners, and four feet deep, rounding every way at the bottom. To the top of the basket is fixed a strong iron curve or handle, with an eye or ring in the middle; and to one side of the basket, near the top, is fixed a small cord, or guide-rope, of about the length of the pole. When the pole is raised, and set against a house over the window from which any persons are to escape, the manner of using it is so plain and obvious, that it need not be described. The most convenient distance from the house for the foot of the pole to stand, where practicable, is about 12 or 14 feet. If two strong iron straps, about three feet long, riveted to a bar cross, and spreading about 14 inches at the foot, were fixed at the bottom of the pole, this would prevent its turning round or slipping on the pavement: and if a strong iron hoop, or ferule, riveted (or welded) to a semicircular piece of iron spreading about 12 inches, and pointed at the ends, were fixed on at the top of the pole, it would prevent its sliding against the wall. When these two last-mentioned irons are fixed on, they give the pole all the steadiness of a ladder; and because it is not easy, except to persons who have been used to it, to raise and set upright a pole of 40 feet or more in length, it will be convenient to have two small poles or spars of about two inches diameter, fixed to the sides of the great pole at about two or three feet above the middle of it, by iron eyes riveted to two plates, so as to turn every way; the lower end of these spars to reach within a foot of the bottom of the great pole, and to have ferules and short spikes to prevent sliding on the pavement, when used occasionally to support the great pole like a tripod. There should be two strong ash trundles let through the pole, one at four feet and one at five feet from the bottom, to stand out about eight inches on each side, and to serve as handles, or to twist the rope round in lowering a very heavy weight. If a block and pulley were fixed at about the middle of the rope, above the other pulley, and the other part of the rope made to run double, it would diminish any weight in the basket nearly one-half, and be very useful in drawing any person up to the assistance of those in the chambers, or for removing any effects out of a chamber, which it might be dangerous to attempt by the stairs.

It has been proved, by repeated trials, that such a pole as we have been speaking of can be raised from the ground, and two or three persons taken out of the upper windows of a house, and set down safely in the street, in the space of 35 seconds, or a little more than half a minute. Sick and infirm persons, women, children, and many others, who cannot make use of a ladder, may be safely and easily brought down from any of the windows of the house on fire by this machine, and by putting a short pole through the handles of the basket, may be removed to any distance without being taken out of the basket. The pole must always have the rope ready fixed to it, and may be conveniently laid up upon two or three iron hooks under any shade or gateway, and the basket should be kept at the watch-house. When the pole is laid up, the two spars should always be turned towards the head of it. The basket should be made of peeled rods, and the pole and spars painted of a light stone-colour, to render it more visible when used in the night.

The fire-escape, exhibited in figure A has the advantages of expedition and security. It consists of a long canvass cradle, attached to a species of ladder work, not unlike the shrouds of a ship, and yet so compact as to occupy but a small space in the buffette of the window, where it can be packed up in a case of wood, which may represent any piece of furniture. The whole is very securely fixed inside of the window-sill, and on an alarm of fire being given, the lowering end may be thrown out into the street, where it will soon be laid hold of by some persons, and brought into the slide or declivity shewn in the figure. A child may then be dropped into the cradle or channel, and will slide into the arms of a person below, without any injury, or risk of any. This article is manufactured by H. Rogers, 10, King-street, West Smithfield.



Davis's Fire *Escape*. This fire-escape is calculated for the use of a parish, and is admirably adapted to the very important end the inventor of it proposed to accomplish. It principally consists of three ladders, A, B, C, as in the following figure, applied to each other by four clasp-irons on the top of each of the two lowermost, which are so contrived, that each ladder may slide into the one beneath it. On the top of the lowermost ladder A, two pulleys are fixed on the inside, over which two ropes *a a* pass, and are situated between the lower one A, and the middle one B. The ropes are made fast to the bottom of the middle one, on each side, in a proper direction with the pulleys on the top. The uppermost ladder C, is attached to the middle one in the same manner, and on the top of it carries two horn pieces D, made of iron, and turned off at each end, similar to 2 horns, which are four feet wide; their ends are sharp, to pitch on each side of a window, and with their points to hold the ladders steady. The three ladders, when shut down, are about 15 feet in height. They are placed perpendicularly in the middle of a framed carriage E F, of 9 feet 6 inches long, and 5 feet 6 inches wide, mounted upon four wheels, F. On each side of the carriage a windlass is affixed; that marked G, on the right side of the carriage, is for the four ropes, *a a*, and *b b*, fixed two to each ladder A B. By turning this windlass, the ladders may be wound out from their standing height of fifteen feet, to forty. Over this windlass is a screw, turned by the winch *d*, by turning which the ladders may be inclined against the house, with all imaginable ease. On the top of the upper ladder C, on the outside, are two pulleys, over which two chains are conducted to the windlass H, on the left side, for the purpose of carrying up a box I. Two boxes of this description travel with the fire-escape, so that in the event of one being filled with small valuables, it may be unhooked, and the other, K, put on, which will save time. The whole of this apparatus may be drawn by one horse, or six men, and when arrived at the scene of danger, may be adjusted in two minutes. If every parish were provided with it, and kept it where it might be brought out without delay, there cannot be a doubt, that many of the serious accidents occasioned by fires would be prevented. The key of access to the machine should be kept at some well-known place, and the machine should be brought out at the first alarm of fire, as it offers the ready means of either ascent or descent, and possesses great superiority over any common or parish ladder, which is useless, or next to useless, unless it accidentally happens to be of the right height.



A method equal to the foregoing, as far as facility of escape is concerned, may be adopted by framing two sides of a ladder similar to a fishing rod; the whole consisting of an indefinite number of pieces of light tough wood, so fitted as to screw the end of one into the socket of the other. The upper end pieces having hooks fixed on them, will enable the inmates to fix the ladder in the sill of a window, and the lower end may be kept steady by persons below, and free from the danger. But after all the methods that might be given, the misfortune is, that in the greater number of such calamities, escape has seldom been effected by such artificial means.

Fire-*Flies*, a species of flies common in America, of which there are two species. The largest is more than an inch in length, it has two feelers, two wings, and six legs. Under its belly is a circular patch, which, in the dark, shines like a candle; and on each side of the head, near the eyes, is a prominent, globular, luminous body, in size about one-third larger than a mustard-seed. Each of these bodies is like a living star, emitting a bright, and not small light; since two or three of these animals, put into a glass vessel, afford a light sufficient to read by without difficulty, if placed close to the book. When the fly is dead, these bodies will still afford considerable light, though less vivid than before; and if bruised, and rubbed over the hands or face, they become luminous in the dark, like a board smeared over with English phosphorus. The other kind is not more than half as large as the former: their light proceeds from under their wings, and is seen only when they are elevated, like sparks of fire, appearing or disappearing at every second.

Fire-*Place.* Economical fire-places should be constructed on the following principles: 1. To place the grate as near the floor as may be. 2. To bring it as forward as may be, consistently with the proper situation of the flue of the chimney, which ought to be directly over the fire, and not larger than sufficient to give free passage at all times to the smoke. 3. The mantle-piece should be as low as possible, without suffering from the heat, or obstructing the proper radiation of it into the room. By these means, a much greater volume of heated air is retained in a room of equal size, than by high grates and large openings.

Fire *Ship*, a vessel filled with combustible materials, and fitted with grappling-irons, to hook and set fire to the enemy's ships. Some English vessels, filled with combustible matter, and sent among the Spanish ships composing the Invincible Armada, in 1588, are said to have given rise to the terrible invention of fire-ships. However, Livy informs us, that the Rhodians had invented a kind of fire-ships, which were used in junction with the Roman fleet in their engagements with the Syrians, in the year before Christ 190. Cauldrons of combustible and burning materials were hung out at their prows, so that none of the enemy's ships durst approach them; these fell on the enemy's galleys, stuck their beaks into them, and at the same time set them on fire. As there is nothing peculiar in the construction of a modern fire-ship, except the apparatus by which the fire is instantly conveyed from one part to another, and from thence to the enemy, it will be sufficient to describe the fire-room in which the combustibles are enclosed, together with the instruments necessary to grapple the ship intended to be destroyed.

The fire-room is built between decks, and extends from the bulk-head at the forecastle to a bulk-head raised behind the main mast. The train enclosed in this apartment is contained in a number of wooden troughs, which intersect each other in different parts of the ship's length, being supported at proper distances by cross-pieces and stanchions. On each side of the ship are six or seven ports about eighteen inches broad, and fifteen inches high, and having their lids to open downward, contrary to the usual method. Against every port is placed an iron chamber. These iron chambers are ten inches long and ¾ in diameter. They are breeched against a piece of wood fixed across the ports, and let into another a little higher. When loaded, they are almost filled with cornpowder, and have a wooden tompion well driven into their muzzles. They are primed with a small piece of quick-match thrust through their vents into the powder, with a part of it hanging out. When the ports are blown open by means of the iron chambers, the port-lids either fall downwards, or are carried away by the explosion. At the time of firing the ship, the iron chamber blows out the port-lid, and opens a passage for the flame. Immediately under the main and fore-shrouds is fixed a wooden funnel, whose lower end communicates with a fire-barrel, (*see* the article Fire-barrels,) by which the flame passing through the funnel is conducted to the shrouds. Between the funnels, which are likewise called fire-trunks, are two scuttles, or small holes, in the upper deck, serving also to let out the flames. Both funnels must be stopped with plugs, and have sail-cloth or canvass nailed close over them, to prevent any accident happening from above to the combustibles laid below. The ports, funnels, and scuttles, not only communicate the flames to the outside and upper-works of the ship, and her rigging, but likewise open a passage for the inward air confined in the fire-room, which is thereby expanded so as to force impetuously through those outlets, and prevent the blowing up of the decks, which must of necessity happen from such sudden and violent refraction of the air as will then be produced. On each side of the bulk-head behind, is cut a hole of sufficient size to admit a trough of the same dimensions as the others. A leading trough, whose foremost end communicates with another trough within the fire-room, is laid close to this opening, from whence it extends obliquely to a sally-port cut in the ship's side. The decks and troughs are well covered with melted rosin. At the time of firing either of the leading troughs, the flame is immediately conveyed to the opposite side of the ship, whereby both sides burn together.

The lieutenant's cabin is on the starboard-side, and the master's cabin on the larboard; the captain's cabin is separated from these by the bulk-head. The stores for a fire-ship of 150 tons are—

8	Fire-barrels.	1	Quick-match barrel.
12	Iron chambers	30	Dipped curtains.
209	Bavins, single dipped.	150	Long reeds, single dipped.
24	Port-fires.	75	Short reeds, single dipped.
3½	Priming composition barrels.	75	Short reeds, double dipped.
		60	Hand grenadoes.

The quantity of composition for preparing the stores of a fire-ship is exhibited in the following statement:

For 8 barrels.—Corn-powder, 960 lbs.; pitch, 480; tallow, 80.

For 3½ barrels, priming composition.—Saltpetre, 175 lbs.; sulphur, 140; corn-powder, 350; rosin, 21; oil, 11 pts.

For the curtains, bavins, and reeds for the ship, and sulphur for salting them.—Sulphur, 200 lbs.; pitch, 350; rosin, 175; tallow, 50; tar, 25.

Total.—Saltpetre, 175 lbs.; sulphur, 340 lbs.; corn-powder, 1310 lbs.; pitch, 830 lbs.; rosin, 196 lbs.; tallow, 130 lbs.; tar, 25 lbs.; oil, 11 pts.

For reeds for the barrels, 160 lbs. being one-fifth of the whole of the last article.

The reeds are made up in small bundles of about a foot in circumference, cut even at both ends, and tied together in two places. They are distinguished into two kinds, *viz.* the long and short; the former of which are four feet, and the latter two feet five inches in length. One part of them are singly dipped, *i. e.* at one end; the rest are dipped at both ends in a kettle of melted composition, and being immersed about seven or eight inches in this preparation and then drained, they are sprinkled over with pulverized sulphur upon a tanned hide.

The bavins are made of birch, heath, or other brushwood, which is tough and readily kindled. They are usually two or three feet in length, and have all their bushways lying one way, the other ends being tied together with small cords. They are dipped in composition at the bush ends, whose branches are afterwards confined by the hand, to prevent them from breaking off by moving about; and also to make them burn more fiercely. After being dipped in the same manner as the reeds, they are also sprinkled with sulphur.

Quick-match is formed of three strands, drawn into length, and dipped into a boiling composition of white-wine-vinegar, saltpetre, and meal or corn powder. After this immersion it is taken out hot and laid in a trough, where some mealed powder, moistened with spirits of wine, is thoroughly incorporated with the twists of the cotton, by rolling it about therein. Thus prepared they are taken separately and drawn through mealed powder, then hung upon a line till dried, by which they are fit for immediate service.

Port-fires are frequently used by the artillery-men in preference to matches, to set fire to the powder or composition. They are distinguished into wet and dry port-fires. The composition of the former is saltpetre four, sulphur one, and mealed powder four. When these materials are thoroughly mixed and sifted, the whole is to be moistened with a little linseed oil, and rubbed between the hands till the oil is imbibed by the composition. The preparation for dry port-fires is saltpetre four, sulphur one, mealed powder two, and antimony one. These compositions are driven into small paper cases, to be used whenever necessary.

Four of the eight fire barrels (according to the stores mentioned above for a fire-ship of 150 tons) are placed under the four fire-trunks, and the other four between them, two on each side of the fire-scuttles, where they are securely cleated to the deck. The longest reeds are put into the fore and aft troughs and tied down; the shortest reeds are laid in the troughs athwart, and tied down also. The bavins, dipped at one end, are tied fast to the troughs over the reeds, and the curtains are nailed up to the beams in equal quantities on each side of the fire-room. The remainder of the reeds are placed in a position nearly upright, at all the angles of every square in the fire-room, and there laid down. If any reeds are left, they are to be put round the fire-barrels and other vacant places, and there tied fast.

Instructions to Prime.—Take up all your reeds, one after another, and strew a little composition at the bottom of all the troughs under the reeds, and then tie them gently down again: next strew composition upon the upper part of the reeds throughout the fire-room, and upon the said composition lay double quick-match upon all the reeds in all the troughs: the remainder of the composition strew over all the fire-room, and then lay your bavins loose.

Cast off all the covers of the fire-barrels, and hang the quick-match loose over their sides, and place leaders of quick-match from the ends into the barrels, and from thence into the vent of the chambers in such a manner as to be certain of their blowing open their ports, and setting fire to the barrels. Two troughs of communication from each door of the fire-room to the sally-ports, must be laid with a strong leader of quick-match four or five times double; also a cross piece to go from the sally-port, when the ship is fixed, to the communication-trough, laid with leaders of quick-match, that the fire may be communicated to both sides at once. What quick-match is left, place so that the fire may be communicated to all parts of the room at once, especially about the ports and fire-barrels, and see that the chambers are well and fresh primed.

The port-fires used for firing the ship, burn about twelve minutes; great care must therefore be taken to have no powder on board when the ship is fired.

The sheer-hooks are fitted so as to fasten on the yard-arms of the fire-ship, where they hook the enemy's rigging. The fire-grapplings are either fixed on the yard-arms or thrown by hand, having a chain to confine the ships together, or fasten those instruments which are necessary.

When the commanding officer of a fleet displays the signal to prepare for action, the fire-ships fix their sheer-hooks, and dispose their grapplings in readiness. The battle being begun, they proceed immediately to prime and prepare their fire-works. When they are ready for grappling, they inform the admiral thereof by a particular signal.

To avoid being disabled by the enemy's cannon during a general engagement, the fire-ships continue sufficiently distant from their line of battle, either to windward or to leeward. They cautiously shun the openings or intervals of the line where they would be directly exposed to the enemy's fire, from which they are covered by lying on the opposite side of their own ships. They are attentively to observe the signals of the admiral or his seconds, in order to put their designs immediately in execution. Although no ship of the line should be previously appointed to protect any fire-ship except a few of the smallest particularly destined to this service, yet the ship before whom she passes in order to approach the enemy, should escort her thither, and assist her with an armed boat, or whatever succour may be necessary in her situation.

The captain of the fire-ship should himself be particularly attentive that the above instructions are punctually executed, and that the yards may be so braced, when he falls alongside the ship intended to be destroyed, that the sheer-hooks and grapplings fastened to the yard-arms, &c. may effectually hook the enemy. He is expected to be the last person who quits the vessel, and being furnished with every necessary assistance and support, his reputation will greatly depend on the success of his enterprize.

Fire, *Wild*, a factitious fire, which burns even under water. It is composed of sulphur, pitch, nitre, and various other combustible materials; and is very hard to extinguish. Chemistry, however, has supplied a still more destructive kind of wild-fire, in the union of nitrous acid with oil of turpentine. These two liquids, separately, are perfectly cold; but when suddenly mixed, produce a flame not easily extinguished.

To make Artificial Fire-works.—Artificial fire-works are of two kinds, those made of gunpowder, nitre, and other inflammable substances and filings of the metals, camphor, &c. and those produced by hydrogen or inflammable air. Those made with gunpowder are well known, and are called rockets, fire-wheels, tourbillons, &c. Of these, the most usual are rockets; which are made by ramming into strong cylindrical paper cases put into wooden moulds, like small hollow columns, powdered gunpowder, or the ingredients of which it is composed, *viz.* saltpetre, sulphur, and charcoal, very dry. To represent a fiery rain falling from the rocket, mix among your charge a composition of powdered glass, filings of iron, and saw-dust: this shower is called the peacock's tail, on account of the various colours exhibited. Camphor mixed with the charge, produces white or pale fire; resin a reddish colour, sulphur a blue, sal ammoniac a green, antimony a reddish yellow, ivory shavings a silvery white, pitch a deep or dark coloured fire, and steel filings, beautiful coruscations and sparks. Sticks are fastened to the rockets, by which they are projected into the air, after they have been lighted: the charge burning with great intensity at one end, acts upon the air, which, in its turn, re-acts upon the rocket, and causes it to ascend, on the same principle as a boat is put off by a man in it, who pushes against the shore with a boat-hook. Fire-works by means of *inflammable air* are the most elegant; and being free from smell or smoke, may be exhibited in a room without any disagreeable effect.

FIRING, in the Military art, denotes the discharge of small arms by platoons, standing, advancing, or retreating; or in oblique or hedge firing. Platoons fire from the right and left alternately, except the centre platoon of the regiment, which being in charge of the colours, remains loaded. Hedge firing is by two deep; oblique is either to the right or left, according to the situation of the object. Parapet and banquette firing depend on various circumstances—the position of the enemy. Square firing is performed in hollow square, when each front is divided into four divisions, and the flanks of the square being the weakest, are covered by four platoons of grenadiers.

FIRKIN, an English measure of capacity, for things liquid, being the fourth-part of the barrel. It contains eight gallons of ale, soap or herrings, in weight 50lbs.; and nine of beer.

FIRLOT, a dry measure used in Scotland, containing 21¼ pints of that country; the barley firlot has, however, 31 standard pints in it. The wheat firlot contains 2211 cubic inches; the English bushel 2178 cubical inches. The Scotch wheat firlot is, therefore, 33 cubical inches larger than the English bushel.

FIRMAMENT (*firmamentum*, Latin). This word has been used with great latitude, as well by the sacred writers, as by poets and astronomers. Some old astronomers consider the orb of the fixed stars as the firmament; but in Scripture, and in common language, it is used for the middle regions, or the space or expanse appearing like an immense concave hemisphere. Many astronomers, both ancient and modern, accounted the firmament a fluid matter; but those who gave it the name of firmament must have considered it as a solid.

FIRMNESS, in Philosophy, denotes the consistence of a body, or that state wherein its sensible parts cohere, or are united together, so that a motion of one part induces a motion of the rest. In which sense firmness stands opposed to fluidity. *See* Cohesion.

FIRST Fruits, in the church of England, are the profits of every spiritual benefice for the first year, according to the valuation thereof in the king's books.

FISC, in Civil Law, the treasury of a prince or state, or that to which all things due to the public do fall. Hence, the *Fiscal* is the officer who has charge of the said treasury.

FISH, a machine employed to hoist and draw up the flukes of a ship's anchor towards the top of the bow, in order to stow it after it has been catted; it is composed of four parts, *viz.* the pendant, the block, the hook, and the tackle, which with their uses, are described under the article Davit.

Fish, is also a long piece of timber, convex on one side and concave on the other, used to strengthen the lower masts, or the yards when they are sprung, or have received some damage in battle, or in tempestuous weather, &c. to effect which they are well secured by stout rope called woolding.

Fish *Gig*, an instrument used to strike fish at sea; it consists of a staff with three, four, or more barbed prongs of steel, and a line fastened to the end on which the prongs are fixed; to the other end is fitted a piece of lead, which gives additional force to the stroke, and causes the points to turn upwards after the fish is penetrated.

FISH *Room*, a space between the after-hold and the spirit-room.

FISHERY, a place where great numbers of fish are caught, as *salmon* in the lochs of Scotland, *herrings* among the Hebrides, *pilchards* along the coast of Cornwall, *cod* on the banks of Newfoundland, and *whales* in Greenland. *Free Fishery*, in Law, is a royal franchise—an exclusive right of fishing in a public river; though some have considered this *free fishing* not as a royal grant. *Fishery* denotes also the commerce of fish, more particularly the catching of them for sale. To encourage the herring fisheries among the Hebrides, from the time of James V. of Scotland till the year 1825, both the Scots and English governments protected, patronized, and even allowed bounties to the herring fishers of these kingdoms; but these bounties are now withdrawn, because there is ample capital, and a sufficient spirit of competition to continue them as private sources of emolument, without the attention of his majesty's ministers. *Cod Fishery*, on the banks of Newfoundland, is of two kinds; the one green or white cod, and the other dried or cured cod—each being the same species of fish, only differently cured and prepared for the market. The former are salted in barrels for use; the latter salted, and then dried in the sun, and smoked. The best season is, from the beginning of February to the end of April. The roes and tongues of cod fish are preserved separately, and the livers melted into oil.

The Lobster Fishery, along the British channel, and on the coast of Norway, whence this shell fish are brought to London for sale; also in the Frith of Edinburgh, and on the coast of Northumberland. By law, no lobster is to be taken under 8 inches long, from the peak of the nose to the end of the middle fin of the tail; nor dare the fishermen take any on the coast of Scotland from the 1st of June to the 1st of September, by 9 Geo. II. cap. 33.

Mackerel Fishery, on the French and English coasts, is usually from April to August, and the fish are taken with the line, or by means of nets.

The mackerel fishery is an object of great commercial importance to the inhabitants of most of the countries on the shores of which these fish abound. During the summer season they approach our coasts in immense shoals, and are generally caught in what are called seine nets. From June to August many of our markets are supplied with them, but as they become putrid sooner than most other fish, they cannot be carried to any great distance, nor be kept for any great length of time. On this account it is that they are allowed to be sold in the streets of London on Sundays, and in Catholic countries on Sundays and festivals. When quite fresh, mackerel are an excellest fish for the table, and are in best season from May to July. Both in Italy and in England they are often pickled with vinegar and spices, and sometimes with bay leaves intermixed. By the inhabitants of many parts of the north of Europe they are salted; and in this state constitute a cheap and very important article of subsistence. In Scotland they are frequently cured in the same manner as herrings.

The Oyster Fishery, at Colchester, in Essex, Milton and Feversham in Kent, the Isle of Wight, the swales of the Medway, and Tenby on the coast of Wales, is carried on from September till May. The best oysters are of a middle size; they are dragged up by a net, (with an iron scraper at the mouth,) which is dragged by a rope from a boat over the beds; and then stored in large pits formed for the purpose, and furnished with sluices, through which at spring tides the salt water is suffered to flow. In these pits they acquire their full quality, and become fit for the table in six or eight weeks. The most delicious oysters are considered to be those which are fattened in the salt-water creeks near Milton and Colchester. Oysters are out of season during the summer time, the period at which they deposit their spawn, and which commences in the month of April. Each spawn has the appearance of a drop of candle-grease, and adheres to rocks, stones, or other substances on which it happens to be deposited. In some oyster beds old shells, pieces of wood, &c. under the denomination of *cultch*, are purposely thrown in to receive the spawn. From these, in the month of May, the oyster fishers are allowed to separate the spawn for the purpose of transferring it to other beds; but they are required, under certain penalties, to throw the cultch in again, that the beds may be preserved for the future; unless the spawn should be so small as not with safety to be separable from the cultch. Oysters are considered to be first fit for the table when about a year and half old; and they are among the few animals which in Europe are not merely eaten raw, but even in a living state. Oysters are also eaten cooked in various ways, as sauce to different kinds of fish, and pickled. The *shells*, like those of other testaceous animals, consist of calcareous earth in combination with animal glue; and by calcination, they yield a pure kind of quick lime. In this state they are not only useful as lime, but are also frequently employed by stationers and attorneys as pounce for rubbing upon parchment previously to its being written upon.

The Pilchard Fishery, on the coasts of Cornwall and Devonshire, from June to September; and on the coast of Bretagne in France, and the coast of Dalmatia, is a very lucrative concern, from the great abundance of these fish that are taken.

The Salmon Fishery, in the Tweed, the Clyde, the Tay, the Dee, the Don, the Spay, the Tyne, the Trent, the Severn, and the Ban, &c. is at its height in the summer season; the hotter the weather, the more plentiful generally the fish.

The Sturgeon Fishery, in the Volga, the Caspian sea, and the *Tunny Fishery*, in the Mediterranean, employ a great number of men. The *Turbot Fishery*, on the Dutch coast, finds a profitable sale in London.

FISHES, in Heraldry, are emblems of silence and watchfulness, and are borne either upright, embowed, extended, endorsed respecting each other, surmounting one another, &c. Or they may be *cant* emblems, as a salmon borne by a person of that name, the fish being perpendicular; a cod, by the *Cod* family; a herring, by the *Herrings*, &c.

FISHES. To define these would be superfluous; but their general physiology deserves attention. Like amphibious animals, the hearts of fishes are unilocular, or consist but of one cavity, and their blood is less warm than that of quadrupeds and birds. The organs of breathing are the *gills*, equivalent to the lungs in man; and these consist of numerous blood-vessels. The generality of fishes are covered with scales, analogous to the hair of quadrupeds and the feathers of birds.

The *fins*, the chief instruments of motion, consist of a certain number of elastic rays of processes, either of one single piece in the form of a spine, or of jointed pieces. The strong or spiny rays are placed at the fore part of the fin, and the soft or jointed rays towards the back part. By the various flexures of these organs, the movements of fishes are conducted; the perpendicular fins, situated on the back or upper part of the animal, keeping the body in equilibrio, while the *tail* operates as a *rudder* at the stern of a vessel, and the side or breast-fins as *oars*. The stomach is large, the intestines far shorter than in quadrupeds and birds: and the liver is very large, usually placed on the left side.

The *air-bladder*, or swimming bladder, is a very highly curious and important organ, lying closely beneath the backbone, and provided with a very strong muscular coat, which gives it the power of contracting at the pleasure of the fish, so as to condense the air with which it is filled, and thus enable the animal to *descend* to any depth, and again to *ascend* by being restored to its largest size. Some fishes are destitute of the air-bladder, yet remain always at the bottom; as the whole tribe of flat-fish. The *teeth* are, in some tribes, large and strong, in others, very small; in some, sharp; in others, obtuse; in some, numerous; and in others, few. Sometimes they are placed in the jaws; sometimes in the palate or tongue; or, even at the entrance of the stomach. The *eyes* are, in general, large, flattened, or less convex than in quadrupeds and birds. In return, the central part of the eye, or what is called the crystalline humour, is of a globular shape, to give the animal the necessary power of vision, and to compensate for the comparative flatness of the cornea.

The organ of *smelling*, in fishes, is large; and they have the power of contracting or dilating it at pleasure. This sense is extremely acute. The organ of *hearing* differs, in some particulars, from that in other animals, and is modified according to the nature of the fish. They are entirely destitute of *voice.* The particular kind of sound or chirp, which some tribes are observed to make, on being first taken out of the water, is entirely owing to the sudden expulsion of air from their internal cavities. The greater number of fishes are *oviparous*, producing soft eggs, usually known by the name of spawn. There have been 200,000 ova or eggs found in a *carp;* in a *perch*, weighing one pound two ounces, 69,216; in a carp of eighteen inches, 342,144; in a sturgeon of one hundred and sixty pounds, there was the enormous number of 1,467,500!!! The age of fish is determinable by the number of concentric circles of the vertebræ or joints of the back-bone. In the Linnæan arrangement of fishes, the under or belly-fins are termed *ventral*, and are considered analogous to the feet in quadrupeds; and it is from the presence or absence of the fins, that the divisions are instituted.

> Far as creation's ample range extends,
> The scale of sensual, mental powers, ascends:
> Mark, how it mounts to man's imperial race,
> From the green myriads in the peopled grass:
> What modes of sight betwixt each wide extreme,
> The mole's dim curtain, and the lynx's beam:
> Of smell, the headlong lioness between,
> And hound sagacious, on the tainted green:
> Of hearing, from the life that fills the flood,
> To that which warbles thro' the vernal wood!
> The spider's touch, how exquisitively fine!
> Feels at each thread, and lives along the line:
> In the nice bee, what sense so subtly true!
> From poisonous herbs extracts the healing dew:
> How instinct varies in the groveling swine,
> Compar'd, half-reasoning elephant, with thine!
> 'Twixt that, and reason, what a nice barrier!
> For ever separate,—yet for ever near!

The fishes are divided into six orders, namely; 1. Apodes: 2. Jujulares: 3. Thoracici: 4. Abdominales: 5. Branchiostegi: 6. Chondropterygii.

1. Apodal fish have bony gills; and no ventral fins, as the *eel.* 2. Jugular fish have bony gills; and the ventral fins situated directly under the pectoral fins, as the *cod, haddock*, and *whiting.* 3. Thoracic fish have bony gills; and the ventral fins situated directly under the pectoral fins, as the *perch* and *mackerel.* 4. Abdominal fish have bony gills; and the ventral fins on the belly behind the pectoral fins, as the *salmon, herring*, and *carp.* 5. Branchiostegeous fish have their gills destitute of bony rays, as the *sucker.* 6. Chrondropterygeous fish have cartilaginous fins, as the *sturgeon, shark*, and *skate.*

FISHING, *see* ANGLING. With respect to *the right of fishing*, and the *property of fish*, where the lord of the manor hath land on both sides of a river, it is good evidence that he hath a right of fishing; but where a river ebbs and flows, and is an arm of the sea, then it is common to all. Thus in the Severn, &c. the soil belongs to the owners of the land on each side, and the soil of the river is in the king, but the fishing is common to all. He who is owner of a private river, or pond, hath a property in the fish; and there needs no privilege to make a fishpond.

FISSURES, in the History of the Earth, are certain eruptions that horizontally or parallely divide the several strata of which the body of the terrestrial globe is composed.

FISTULA, in Surgery, a deep, narrow, and callous ulcer, generally arising from abscesses, chiefly in the arms.

FISTULARIA, pipe fish, a genus of the order abdominales, grows to the length of three or four feet, and is of the shape of an eel.

FITTER, in Chemistry, any instrument or machine, whose use and effect with regard to liquids is the same that the sieve or searce has in dry matters. Water is freed from its impurities by basins of porous stone.

FITTING-OUT, the act of furnishing a ship with sufficient masts, sails, yards, ammunition, artillery, cordage, anchors, provisions, stores, and men, for the voyage or purpose to which she is appointed.

FIXED BODIES, generally denote those bodies which neither fire nor any corrosive has such an effect on, as to reduce or resolve them into their component elements, or absolutely to destroy them. Of fixed bodies, the principal are gold, platina, silver, precious stones, particularly the diamond, salts, &c.

FIXED *Ecliptic*, a certain imaginary plane, which never changes its position in the heavens from the action of any of the parts of the solar system on each other; but, like a centre of inertia, remains immoveably fixed. The existence of such a plane is demonstrated by Laplace, who has shewn the method of determining it from the situations, velocities, masses, &c. of the planets and other bodies. *See* ZODIAC.

FIXED *Signs* of the *Zodiac*, an arbitrary denomination which some astronomers have given to the signs Taurus, Leo, Scorpio, and Aquarius. The particular corresponding season being supposed most fixed when the sun is in those signs.

FIXED *Stars*, are those which constantly maintain the same relative position with regard to each other, in contradistinction to the planets and comets which are constantly changing their relative positions. *See* CONSTELLATION, HEMISPHERE, and STAR.

FIXITY, or FIXEDNESS, in Philosophy, the quality of a body which denominates and renders it fixed; or a property which enables it to endure fire, and other violent agents. A body may be said to be fixed in two respects; *viz.* 1. When, on being exposed to the action of fire, or a corrosive menstruum, its particles are indeed separated, and the body rendered fluid, but without being resolved into its first elements: and, 2. When the body sustains the active force of the fire, or menstruums, whilst its integral parts are not carried off by fume. Each kind of fixity is the result of a strong or intimate cohesion between the particles of the body.

FLAG, a certain banner by which an admiral is distinguished at sea from the inferior ships of his squadron; also the colours by which one nation is distinguished from another. In the British navy, flags are either red, white, or blue, and are displayed from the top of the main-mast, fore-mast, or mizzenmast, according to the rank of the admiral.

The first flag in Great Britain is the royal standard, which is only to be hoisted when the king or queen is on board the vessel; the second is that of the anchor of hope, which characterizes the lord high admiral, or lords commissioners of the admiralty; and the third is the union flag, appropriated to the admiral of the fleet, who is the first officer under the lord high admiral. The navy-board, custom-house, &c. have each their respective flags.

When the flag is displayed at the main-top-gallant-mast-head, the officer distinguished thereby is known to be an admiral; when from the fore-top-gallant-mast-head, a vice-admiral; and when from the mizzen-top-gallant-mast-head, a rear-admiral; the next flag after the union, is white at the main; and the last, which characterizes an admiral, is blue at the same mast-head. For a vice-admiral the first flag is red, the second white, and the third blue, at the fore-top-gallant-mast-head. The same order is observed with regard to rear-admirals, whose flags are displayed at the mizzen-top-gallant-mast-head; the lowest flag in our navy is accordingly blue at the mizzen. All the white flags have a red St. George's cross in them, in order the more readily to be distinguished from the French white flag with a white cross.

Besides the national flag, merchant ships frequently bear lesser on the mizzen-masts, with the arms of the city where the master ordinarily resides, and on the fore-mast with the arms of the place where the person who freights them lives.

When a council of war is held at sea, if it be on board the admiral, they hang a flag on the main-shrouds; if in the vice-admiral, in the fore-shrouds; and if in the rear-admiral, in the mizzen-shrouds. The flags borne on the mizzen are particularly called Gallants.

To heave out the flag, is to put out or hang abroad the flag. To hang out the white flag, is to call for quarter; or it shews when a vessel arrives on a coast that it has no hostile intention, but comes to trade, or the like. To hang out the red flag, is to give a signal of defiance and battle. To lower, or strike the flag, is to pull it down upon the cap, or to take it in, out of the respect or submission due from all ships or fleets inferior to those any way justly their superiors. To lower or strike the flag in an engagement, is a sign of yielding.

The way to lead a ship in triumph, is to tie the flags to the shrouds, or the gallery in the hind part of the ship, and let them hang down towards the water, and tow the vessels by the stern. Livy relates that this was the way the Romans used those of Carthage.

Flag *Officer*, a term synonymous to admiral.

Flag *Ship*, a ship in which an admiral's flag is displayed.

Flag *Staff*, is generally a continuation of the top-gallant-mast above the top-gallant rigging, but is sometimes, especially in guard-ships, a spar, occupying the place of the top-gallant-mast, and is only of use to display the flag or pendant; when it is a continuation of the top-gallant-mast, it is frequently termed the royal mast.

FLAGEOLET, a little flute, used chiefly by shepherds and country people.

FLAIL, an instrument for thrashing corn, that consists of, 1. the hand-staff, which the labourer holds in his hand; 2. the swiple, or that part which strikes the corn; 3. the caplins, or leathern thongs that bind the hand-staff and swiple; 4. the middle band, being the leathern thong, or fish-skin, that ties the caplins together.

FLAIR, is a phrase at sea: when a ship being housed in near the water so that the work hangs over a little too much, and thus is let out broader aloft than the due proportion will allow, the seamen say that the work doth flair over.

FLAKE, a sort of platform made of hurdles, used for drying codfish in Newfoundland; they are usually placed near the shores of fishing-harbours. Flake signifies also a small stage hung over a ship's side to caulk or repair any breach. We speak also of a flake of snow. *See* Snow.

FLAMBEAU, a large taper, made of hempen wicks, by pouring melted wax on their top, and letting it run down to the bottom. This done, they lay them to dry; after which they roll them on a table, and join four of them together by means of a red-hot iron; and then pour on more wax till the flambeau is brought to the size required. Flambeaus are of different lengths, and made either of white or yellow wax. They serve to give light in the streets at night, or on occasion of illuminations.

FLAME, the subtlest and brightest part of fuel, ascending above it in a pyramidal or conical figure, and has been conjectured by Newton to be a vapour red-hot; which, however, seems to be but an imperfect idea. We should rather say, that flame is an instance of combustion, whose colour will be determined by the degree of decomposition which takes place. If it be very imperfect, the most refrangible rays only will appear; if very perfect, all the rays will appear, and the flame will be brilliant in proportion to this perfection. There are flames, however, which consist of burning particles, whose rays have partly escaped before they ascended in the form of vapour; such would be the flame of a red-hot coal, if exposed to such a heat as would gradually disperse it into vapour. When the fire is very low under the furnace of an iron-foundery, at the upper orifice of the chimney a red flame of this kind may be seen, which is different from the flame that appears immediately after fresh coals have been thrown on the fire; for, in consequence of adding such a supply to the burning fuel, a vast column of smoke ascends, and forms a medium so thick as to absorb most of the rays excepting the red.

FLAMINGO. *See* Phœnicopterus.

FLAMSTEED, a celebrated English astronomer, and the first astronomer royal, was born at Derby, in the year 1616, and very early discovered a great genius and taste for astronomical subjects; having, while yet a youth, computed both solar and lunar eclipses, and occultations of the moon and stars. He possessed more zeal and application in the pursuit of scientific knowledge than the first astronomer royal, and scarcely any man ever attained a higher respect amongst his contemporaries. In common life he was free and easy of access, and pleased with the company of those who, with scientific research, could unite their share in the convivial intercourse of life. Flamsteed's great work on astronomy, in 3 vols. fol. comprises a catalogue of the right ascensions, polar distances, longitudes, and magnitudes of nearly 3000 fixed stars. The preface to this volume contains an account of all the astronomical observations made before his time, with a description of the instruments employed, and much other curious and highly important matter.

FLANK, in the Manege, the sides of a horse's buttock; or more properly, the extremities of the belly where the ribs are wanting. In a well-made horse the flanks are full, and the distance short between the last rib and the haunch bone, which is properly the flank.

Flank, in War, the side of a battalion, army, &c. in contradistinction to *front* and *rear*. In Fortification, the part of a bastion which reaches from the curtain to the face. *See* Bastion.

FLANNEL, a woollen stuff, composed of a woof and warp, and woven after the manner of baize. Various theories have been adopted to prove the utility of flannel as an article of dress; it is unquestionably a bad conductor of heat, and on that account very useful in cold weather; this is accounted for from the structure of the stuff; the fibres touch each other very slightly, so that the heat moves slowly through the interstices, which being already filled with air, give little assistance in carrying off the heat. In the town of Rochdale, and the adjacent villages, there are manufactured, every week, of flannels and baizes, about 20,000 pieces, of 46 yards each, making 47,840,000 yards per annum. It is supposed that 17,840,000 yards are exported; the remaining 30 millions of yards are consumed in the United Kingdom, being an average of about 1½ yard for each individual. Some good flannels are manufactured in Wales; a few coarse ones at Keswick, and some other towns and villages in the kingdom. A few are manufactured on the Continent, and works for that purpose are now erecting in America; but the whole of the flannels manufactured on the globe, besides those manufactured in Rochdale and its immediate vicinity, are not equal in quantity to those made there. The price of flannels is from 5*d.* to 3*s.* per yard; and the average may be stated at from 13*d.* to 14*d.* per yard; so that the annual value of the manufacture may be stated at about three millions sterling. The wool costs fully one-half of the wholesale selling price; the oil, labour, and finishing, &c. constitute nearly the other half.

FLAT, a level ground lying at a small depth under the surface of the sea; otherwise called a Shoal, or Shallow.

To Flat *in*, the action of drawing in the aftmost clue of a sail towards the middle of a ship, to give the sail the greater power of turning the vessel; thus, if the mizzen or after sails are flatted in, it is evident that the intention is to carry the stern to leeward, and turn the head nearer to the wind; and if the head-sails are flatted in, the intention is accordingly to make the ship fall off, when, by design or accident, she has come so near the wind as to make the sails shiver; hence—

Flat *in forward*, is the order to draw in the jib and fore-top-mast stay-sail sheets towards the middle of the ship; this operation is seldom necessary, except in light breezes of wind, when the helm has not sufficient government of the ship.

Flat, in Music, a character, which before a note signifies that the note is to be sung or played half a tone lower than its natural pitch. A double flat is a character compounded of two flats, signifying that the note before which it is placed is to be sung or played two semitones lower than its natural pitch.

FLAX Dressing, has for many ages been performed in slow and laborious operations, by means of a mallet, a break, &c. which have been used for preparing the flax for the heckle. The break and scutcher, common in Ireland and Scotland, are inferior to the machinery of mills, among the chief of which is the following, to be found in "Gray's Millwright."

Flax *Mill.* (See Plate, *Mills.*) A A, the great water-wheel fixed upon its shaft, and containing 40 aws or float-boards, to receive the water which communicates motion to the whole machinery. B B, a wheel fastened upon the same axle, having, as before mentioned, 102 cogs, to drive the wheel C of 25 teeth, which is fixed upon the middle roller, No. 1. The thick part of this roller is fluted, or rather has teeth all round its circumference. These teeth are of an angular form, being broad at their base, and thinner towards their outward extremities, which are a little rounded, to prevent them from cutting the flax as it passes through betwixt the rollers. The other two rollers, Nos. 2 and 3, have teeth in them of the same form and size as those in the middle roller, whose teeth, by taking into those of these two rollers, turn them both round. The rough flax is made up into small parcels, which being introduced betwixt the middle and upper rollers, pass round the middle one; and this either having rollers placed on its off-side, or being enclosed by a curved board that turns the flax out betwixt the middle and under rollers, when it is again put in betwixt the middle and upper one, round the same course, until it be sufficiently broken or softened, and prepared for the scutching machine. The bearer in which the gudgeon of the roller No. 1 turns, is fixed in the frame at C; and the gudgeons of the rollers Nos. 2 and 3 turn in sliders that move up or down in grooves in the frames S S. The under roller is kept up to the middle one by the weights D D, suspended by two ropes going over two sheaves in the frame S S; their other ends being fastened to a transverse bearer below the sliders in which the gudgeons of the roller No. 3 turn. The weights D D must be considerably heavier than the under roller and sliders, in order that its teeth may be pressed in betwixt the teeth of No. I, to bruise the flax when passing between the rollers. The whole weight of the roller No. 2 presses on the flax which passes between it and No. 1. There is also a box fixed on the upper edge of its two sliders to contain a parcel of stones, or lumps of any heavy metal, so that more or less weight can be added to the roller, as is found necessary. O O, is the large frame that supports one end of the shaft which carries the two wheels A, B, and vertical axle F F; on the lower end of which is fixed the pinion turned by the wheel B, and having 10 teeth. In the axle F, are arms upon which the scutchers are fastened with screwed bolts. These scutchers are enclosed in the cylindrical box E E, having in its curved surface holes or porches at which the handfuls of flax are held in, that they may be cleaned by the revolving scutchers. H H, the fall or course of the water. T T, the sluice, machine, and handle, for raising the sluice to let the water on the great wheel. The gudgeons of the axles should all turn in cods or bushes of brass. K K, the side walls of the mill house. G G, doors. L L, windows. R K, the roof.

FLEAM, in Surgery and Farriery, an instrument for letting a horse or other animal blood.

FLEECY Hosiery, a useful manufacture, in which fine fleeces of wool are interwoven into a cotton piece of the common stocking texture, for making stockings, socks, waistcoats, and other clothing, for persons afflicted with complaints requiring warmth, and for common use in cold climates.

FLEET, a general name given to the British navy; it also denotes any number of ships, whether designed for war or commerce, keeping company together. The admirals of his majesty's fleet are classed into three squadrons, *viz.* the red, white, and blue. When any of these officers are invested with the command of a squadron or detachment of ships of war, the particular ships are distinguished by the colours of their respective squadron: that is to say, the ships of the red squadron wear an ensign whose union is displayed on a red field; the ensigns of the white squadron have a white field, and those of the blue squadron a blue field; the union being common to all three. The ships of war, therefore, are occasionally annexed to any of the three squadrons, or shifted from one to another.

Of whatsoever number a fleet of ships of war is composed, it is usually divided into three squadrons; and these, if numerous, are again separated into divisions. The admiral, or principal officer, commands the centre; the vice-admiral, or second in command, superintends the van-guard; and the operations of the rear are directed by the rear-admiral, or the officer next in rank. *See* the article Division.

The disposition of a fleet while proceeding on a voyage will, in some measure, depend on particular circumstances; as the difficulty of navigation; the necessity of despatch, according to the urgency or importance of the expedition; or the expectation of an enemy in the passage. The most convenient order is probably to range it into three lines or columns, each of which is parallel to a line close hauled, according to the tack on which the line of battle is designed to be formed. This arrangement is more used than any, because it contains the advantages of every other form without their inconveniences. The fleet being thus more enclosed will more readily observe the signals, and with greater facility form itself into the line of battle; a circumstance which should be observed in every order of sailing. *See* the article Engagement.

Merchant-fleets generally take their denomination from the place they are bound to, as the West India fleet, the East India fleet, &c. These in times of peace go in fleets for their mutual protection and assistance: in times of war, besides this security, they likewise procure convoys of ships of war, either to escort them to the places whither they are bound, or only a part of the way, to a certain point or latitude, beyond which they are judged out of danger of privateers, &c.

FLEETING, the act of changing the situation of a tackle when the blocks are drawn together; also of changing the position of the dead-eyes, when the shrouds are become too long, which is done by shortening the shrouds and turning in the dead-eye again higher up; the use of fleeting is accordingly to replace the mechanical powers in a state of action, the force by which they operated being destroyed by the meeting of the blocks or dead-eyes. Fleeting, therefore, is nearly similar to the winding up of a watch or clock.

FLESH, in Anatomy, a fibrous part of an animal body, soft and bloody, being that of which most of the other parts are composed, and by which they are connected together; or, more properly, it is that part of the body where the blood-vessels are so small as only to retain blood enough to preserve their colour red.

FLESHER, in Scotland, is a butcher; and in Glasgow and some other places, there are *corporations of fleshers.*

FLEXIBLE, is the property or quality of a body that may be bent.

FLEXURE, or Flexion, is the bending of a line or figure.

FLINT. This mineral consists of 98 silica, 0·50 lime, 0·25 alumina, 0·25 oxide of iron, and 1·0 loss. Its principal use is for gun-flints, and it is also reduced to a powder, and used in the manufacture of porcelain and glass. The manufacture of gun-flints is exceedingly simple, and a good workman will make 1000 flints a day. The whole art consists in striking the stone repeatedly with a kind of mallet, and bringing off at each stroke a splinter sharp at one end, and thicker at the other. The splinters are afterwards shaped at pleasure, by laying the line at which it is wished they should break, upon a sharp instrument, and then giving it small blows with a mallet.

FLOAT, a raft or quantity of timber fastened together, to be driven along a river by the tide or current.

FLOAT Boards, those boards which are fixed to the rim, or circumference, of undershot water wheels, serving to receive the impulse of the stream, and by which means the mill is put into motion.

FLOATING Bodies, are those which swim on the surface of a fluid, the stability, equilibrium, and other circumstances of which form an interesting subject of mechanical and hydrostatical investigation, particularly as applied to the construction and management of ships and other vessels. The equilibrium of floating bodies is of two kinds, *viz.* stable or absolute, and unstable or tottering. In the one case, if the equilibrium be ever so little deranged, the bodies which compose the system only oscillate about their primitive position, and the equilibrium is then said to be firm, or stable. And this stability is *absolute* if it takes place, whatever be the nature of the oscillations; but it is *relative*, if it only takes place in oscillations of a certain description. In the other state of equilibrium, if the system be ever so little deranged, all bodies deviate more and more, and the system, instead of any tendency to establish itself in its primitive position, is overset, and assumes a new position, entirely different from the former; and this is called a *tottering*, or *unstable*, equilibrium.

We may form a just conception of these two states, by supposing an ellipse placed vertically on an horizontal plane; if the ellipse is in equilibrium on its smaller axis, it is evident that upon a slight derangement, it will tend to regain its original position, after several small oscillations, which will soon be terminated by the friction and resistance of the air; but if the ellipse be placed in equilibrium on its greater axis, if once it deviates from this position, it will continue to deviate more and more, till it finally turns itself on its lesser axis. In the above example, there is this remarkable circumstance; the four positions of equilibrium of the ellipse, on the extremities of its two axes, are alternately stable and unstable; and this takes place in every case. For, suppose two positions of stable equilibrium to take place in any body, and such that there does not exist between them any position of the same kind, if the body be placed in one of these positions, and is made to deviate from it, and to approach the other, according as this deviation is greater or less, the body will either return to its original state, or will arrive at the other position. There will evidently, therefore, be some intermediate position, in which the body will neither tend towards one or the other of the former, but will remain at rest; but this state of equilibrium will be unstable, since, if the body be made to deviate ever so little towards one of the other positions, it will necessarily arrive at it. Hence, it appears, that if a body turning round a fixed axis passes through several positions of equilibrium, they will be alternately stable and unstable.

The stability of a floating body is the greater as its centre of gravity is lower than that of the displaced fluid, or as the distance between these centres is increased; it is for this reason, that ballast is put in the lower part of vessels to prevent them from being overset. The nature of the equilibrium, as to stability, depends on the position of a certain point, called the *centre of pressure;* which term was first adopted by Bouguer, in in his "Traite du Navire."—When the centre of pressure is above that of gravity, the equilibrium is stable; when it is lower than the centre of gravity, the equilibrium is tottering; when this centre coincides with the centre of gravity, the body will remain at rest wherever it is placed, without any tendency to oscillation.

Laplace gives the following rule for determining whether the force which solicits the system, tends to restore it to the same state again when deranged from its primitive position, which is as follows:—If through the centre of gravity of the section of the surface of the water on which a body floats, we conceive a horizontal axis to pass, such that the sum of the products of every element of the section, multiplied by the square of its distance from this axis be less than any other horizontal axis drawn through the same centre, the equilibrium will be stable in every direction; when this sum surpasses the product of the volume of the displaced fluid, by the height of the centre of gravity of the body above the centre of gravity in this volume.

This rule is principally useful in the construction of vessels which require sufficient stability to enable them to resist the effects of storms, which tend to submerge them. In a ship, the axis drawn from the stern to the prow, is that relative to which the sum above mentioned is a minimum; it is easy therefore to ascertain and measure its stability by the preceding rule.

In order that a floating body may remain in equilibrio, it is also necessary that its centre of gravity be in the same vertical line with the centre of gravity of the displaced fluid, otherwise the weight of the solid will not be completely counteracted by the pressure of the displaced fluid. When the lower surface of a floating body is spherical or cylindrical, the centre must coincide with the centre of the figure, since the height of this point, as well as the form of the portion of the fluid displaced, must remain invariable in all circumstances. The place of the centre is determined by the doctrine of forces combined with the elementary principles of hydrostatics, by considering the form and extent of the surface of the displaced portion of the fluid, compared with its bulk and with the situation of its centre of gravity. If a rectangular beam be floating on its surface, the height of the centre of pressure above the centre of gravity will be to the breadth of the beam, as the breadth is to twelve times the depth of the part immersed. Hence, if the beam be square it will float securely, when either the part immersed, or the part above the surface, is less than $\frac{21}{100}$ of the whole, but when it is less unequally divided by the surface of the fluid, it will overset. If however the breadth be so increased as to be nearly one-fourth greater than the depth, it will possess a certain degree of stability, whatever its density may be. *See* ICEBERG.

FLOATING *Breakwater.* This marine contrivance may consist of a series of square frames of timber, connected by mooring chains, or cables attached to anchors, or blocks of marble. The frame-work may be made of logs of Quebec yellow pine, from 30 to 50 feet long, and from 18 to 20 inches square, bolted together very firmly, and increased in height as the situation may be boisterous, in order to break the violence of the agitated waves, and allow the vessels riding within these quadrangular basins more safety and protection. Such *breakwaters* are admirably adapted to bathing-places and swimming stations, since they will always produce smooth water and protect the machines. Indeed, the Editor would recommend the establishment of *floating breakwater* baths at bathing-places on the sea-coast. These might be so framed with reticulated fencing for their sides and bottoms, or with actual net-work, as to afford perfect safety against drowning, even to persons who could not swim. *See* SWIMMING.

FLOOD, the flux of the tide, or the time the water continues rising; called a young flood, quarter-flood, half flood, high flood.

FLOOKING, among Miners, a term used to express a peculiarity in the load of a mine.. The load, or quantity of ore, is frequently intercepted by the crossing of a different substance; in which case the load is moved to one side, and this transient part of the land is called a flooking.

FLOOR OF A ROOM, is best made of good seasoned deal, from 4 to 7 inches broad, and of as great lengths as possible, from 12 to 18 feet. Floors may be laid either *ploughed* or *dooled;* when ploughed, the feather may be worn through, and then the floor looks wretched, besides the greater quantity of nails that feathered flooring requires, render it less desirable than dooled flooring, in which there is neither groove nor feather, and but very few nails; but then this last admits the dust much more than the other.

FLOOR, the bottom of a ship, or all that part on each side of the keel which approaches nearer to an horizontal than a perpendicular situation, and whereon she rests when aground; thus we say, a sharp floor, a flat floor, a long floor, &c.

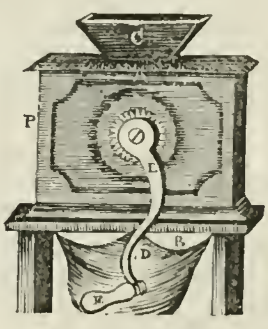
FLOOR *Timbers,* are those parts of the ship's timbers which are placed immediately across the keel, and upon which the bottom of the ship is framed; to these the upper parts of the timbers are united, being only a continuation of floor-timbers upwards.

FLORIN, is sometimes used for a coin, and sometimes for a money of account. The florin coin is of different values. The gold florins are most of them of a coarse alloy, some of them not exceeding thirteen or fourteen carats, and none of them seventeen and a half. As to silver florins, those of Holland are worth about 1*s.* 8*d.*

FLOS, in Chemistry, the most subtile parts of bodies, separated from the more gross parts by sublimation, in a dry form.

FLOTSAM, JETSAM and LAGAN, in Law. Flotsam is when a ship is sunk or cast away, and the goods float on the sea: jetsam is when a ship is in danger of being sunk, and to lighten the ship the goods are thrown overboard, and the ship notwithstanding perishes; and lagan is when the goods so cast into the sea are so heavy that they sink to the bottom, and therefore the mariners fasten to them a buoy or cork, or such other thing that will not sink, to enable them to find them again.

FLOUR MILLS, are put in motion by wind, water, steam, &c. We have before us "the Steel Corn Mill," which, from its being portable, is of great use in armies, on shipboard, and even in private families. Externally, this mill wears the appearance given it in the annexed figure. It is said, this mill will produce flour equal in quality of fineness with the first-rate water or wind mills; and by the simple addition of a couple of extra grinding plates, to shift as occasion may require, this mill becomes at once a general grinding mill for grain, rice, coffee, &c. B is a strong board, on which the work is fixed. DE, a winch to turn the mill. A, the box that covers the internal machinery. C, the hopper: and the engraving of the "*Patent Portable Corn Mill,*" on the Plate *Mills,* is a section of this machine, as you look down upon it when the lid is removed. To regulate the mill lift, the pole 3 out of the ratchet wheel 2, then move the regulator 1 to the right, if you wish the mill set fine, *viz.* for grinding flour, &c.; or to the left, to set it coarser, *viz.* for malt, oats, beans, &c. When the mill is properly regulated, let the pole fall into one of the divisions of the ratchet wheel, by



which the plates will be kept in the position you wish. To ease the friction of the spindle, and make the mill work easy, it is necessary to apply oil frequently to the points marked 4. If a small stone, or other hard substance, should get between the plates and check the working of the mill, it can be instantly relieved by turning the regulator to the left, by which means it will drop out. To clean the mill before using it for flour, run a few handsful of common grain through the plates two or three times, which will remove any dirt that may settle between them. Care should be taken not to set the mill too tight, as it not only makes it work hard, but wears the face of the plates unnecessarily, and in some measure destroys the vegetable quality of the wheat. There is a key to take the mill to pieces if required, or put it together, to perform which no instructions are necessary.

The whole apparatus is contained in a neat iron case, measuring only 13 inches by 8, and 10 inches deep. The movements are rendered simple and effectual, and the mill is so easy to work, that a stout boy will be able to grind as much flour in two or three hours as a family of six or eight people will consume in a week; and it is calculated, that a very few persons can grind and dress sufficient to meet the consumption of a regiment of one thousand men. The London Portable Mill Company, in Cheapside, do not claim the merit of the original invention, but of bringing the French Military Mill to perfection, for general, public, and domestic uses, by facilitating its operations, and by otherwise improving it to an extraordinary degree.

We shall describe a flour mill of the most common sort, as follows. (See Plate, *Mills.*) A B is the water wheel, which is generally from eighteen to twenty-four feet in diameter, reckoned from the uttermost edge of any float-board at A, to that of the opposite one at B. The wheel is fixed upon a very strong axis, or shaft C, one end of which rests on D, and the other on E, within the mill-house. On this shaft, or axis, and within the mill-house, is a wheel F, about 8 or 9 feet in diameter, having cogs all round, which work in the upright staves, or rounds of a trundle G. This trundle is fixed upon a strong iron axis, called the spindle, the lower end of which turns in a brass foot, fixed at H, in a horizontal beam H M, called the bridge-tree; and the upper and of the spindle turns in a wooden bush fixed into the nether millstone, which lies upon beams in the floor I. The top of the spindle above the bush is square, and goes into a square hole in a strong iron cross, called the rynd; under which, and close to the bush, is a round piece of thick leather upon the spindle, which it turns round at the same time as it does the rynd. The rynd is let into grooves in the under surface of the running millstone K, and so turns it round in the same time that the trundle G is turned round by the cog-wheel F. This stone has a large hole quite through its middle, called the eye of the stone, through which the middle part of the rynd and upper end of the spindle may be seen, whilst the four ends of the rynd lie below the stone in their grooves. One end of the bridge-tree which supports the spindle, rests upon the wall, whilst the other is let into a beam, called the brayer. L M. The brayer rests in a mortise at L, and the other end M, hangs by a strong iron rod N, which goes through the floor I, and has a screw-nut on its top at O; by the turning of which nut, the end M of the brayer is raised or depressed at pleasure, and consequently the bridge-tree and the upper millstone. By this means, the upper millstone may be set as close to the under one, or raised as high from it, as is convenient.

The corn will be ground fine or coarse, according to the distance of the millstones from each other. On the top of the box which encloses the millstone, stands a frame for holding the hopper P, to which is hung the shoe Q, by two lines fastened to the hinder part of it, fixed upon hooks in the hopper, and by one end of the string R fastened to the fore part of it, the other end being twisted round the pin S. As the pin is turned one way, the string draws up the shoe closer to the hopper, and so lessens the aperture between them; and as the pin is turned the other way it lets down the shoe, and enlarges the aperture. If the shoe be drawn up quite to the hopper, no corn can fall from the hopper into the mill; if it be let down a little, some will fall; and the quantity will be more or less, according as the shoe is more or less let down; for the hopper is open at bottom, and there is a hole in the bottom of the shoe, not directly under the bottom of the hopper, but nearer the lowest end of the shoe, over the middle eye of the millstone. There is a square hole in the top of the spindle, in which is put the feeder F; this feeder, as the spindle turns round, jogs the shoe three times in each revolution, and so causes the corn to run constantly down from the hopper through the shoe into the eye of the millstone, where it falls upon the top of the rynd, and is, by the motion of the rynd, and the leather under it, thrown below the upper stone, and ground between it and the lower one. The violent motion of the stone creates a centrifugal force in the corn going round with it, by which means it gets farther and farther from the centre, as in a spiral, in every revolution, until it be quite thrown out; and being then ground, it falls through a spout, called the mill-eye, into a trough.

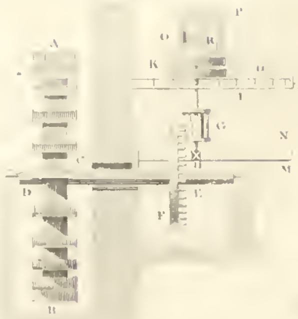
When too much corn is let into the mill, or when the mill is fed too fast, the corn bears up the stone, and is ground too coarse; and besides, it clogs the mill, so as to make it go too slow. When the mill is too slowly fed it goes too fast, and the stones, by their attrition, are apt to strike fire. Both which inconveniences are avoided by turning the pin S backward or forward, which draws up or lets down the shoe, and thus regulates the feeding, as is found convenient; the greater the quantity of water that falls upon the wheel, and the heavier the running millstone is, the faster will the mill bear to be fed, and consequently it will grind the more. And on the contrary, the lighter the stone, and the less the quantity of water, so much slower must the feeding be. But when the stone is considerably worn, and become light, the mill must be fed slowly at any rate; otherwise the stone will be too much borne up by the corn under it, which will make the meal coarse. The power sufficient to turn a heavy millstone, is but very little more than what is necessary to turn a light one; for as it is supported upon the spindle by the bridge-tree, and the end of the spindle that turns in the brass foot therein being but small, the difference arising from the weight is but very inconsiderable in its action against the power or force of the water.

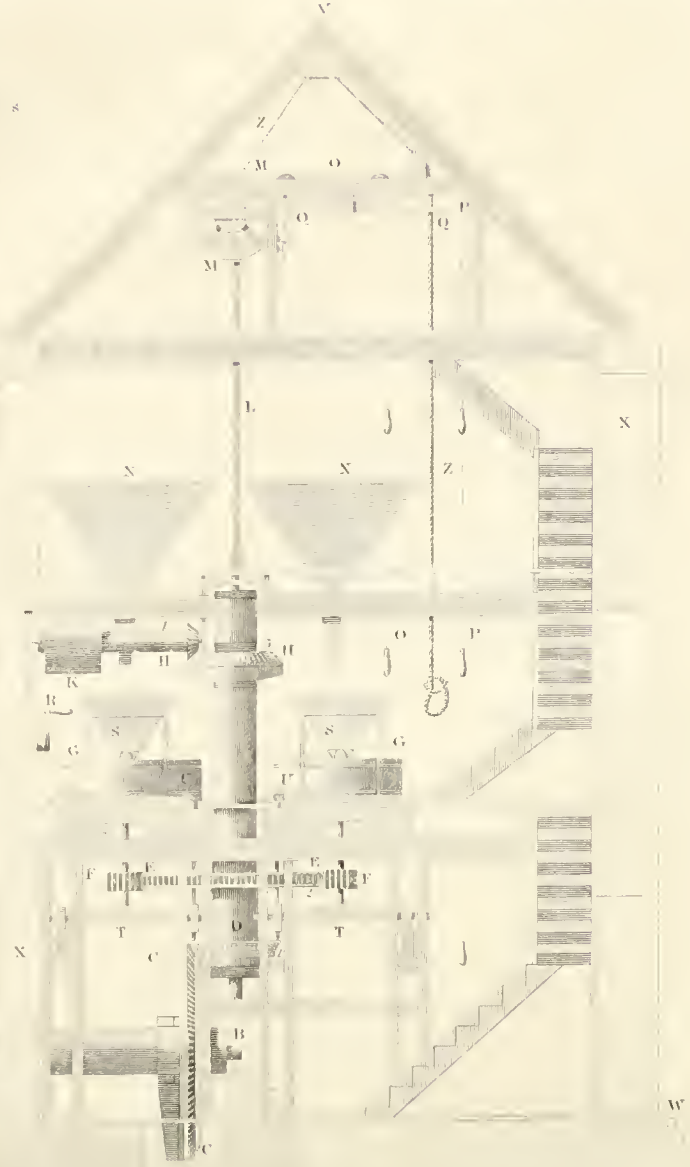
It is natural the corn should be crushed when it comes to a place where the interval between the two millstones is less than its thickness, yet the upper millstone being supported on a point which it can never quit, it does not so clearly appear why it should produce a greater effect when it is heavy, than when it is light; since, if it were equally distant from the nether millstone, it could only be capable of a limited impression: but as experience proves that this is really the case, it is necessary to discover the cause. The spindle of the millstone being supported by a horizontal piece of timber, about nine or ten feet long, resting only on both its ends, by the elasticity of this piece, the upper millstone is allowed a vertical motion, playing up and down; by which movement, the heavier the stones are, the more strongly is the corn pressed between them. Both the upper and under millstones have channels cut into them, (*see figs.* 1 & 2, *page* 319,) obliquely from the centre to the circumference, in order to cut and grind the corn. These furrows are cut perpendicularly on one side, and obliquely on the other, which gives each furrow a sharp edge; and in the two stones they come, as it were, against one another, like the edges of a pair of scissars, and so cut the corn to make it grind the easier, when it falls upon the places between the furrows. These are cut the same way in both stones, when they lie upon their backs, which makes them run crossways to each other when the upper stone is inverted, by turning its furrowed surface towards that of the lower; for if the furrows of both stones lay the same way, a great deal of the corn would be driven onward in the lower furrows, and so come out from between the stones, without being cut or bruised. Also the grinding surface of the under stone is a little convex from the edge to the centre, and that of the upper stone a little concave, so that they are farthest from one another in the middle, and approaching gradually nearer towards the edges. By this means the corn, at its first entrance between the stones, is only bruised; but as it goes farther on towards the circumference or edge, it is cut smaller and smaller, and at last finely ground, just before it comes out from between them. When the furrows become blunt or shallow by wearing, the running stone

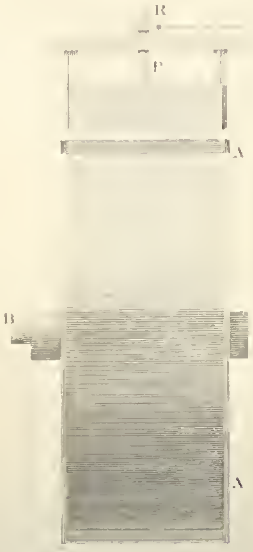
MILLS.

Flour Mill,

of the commonest sort

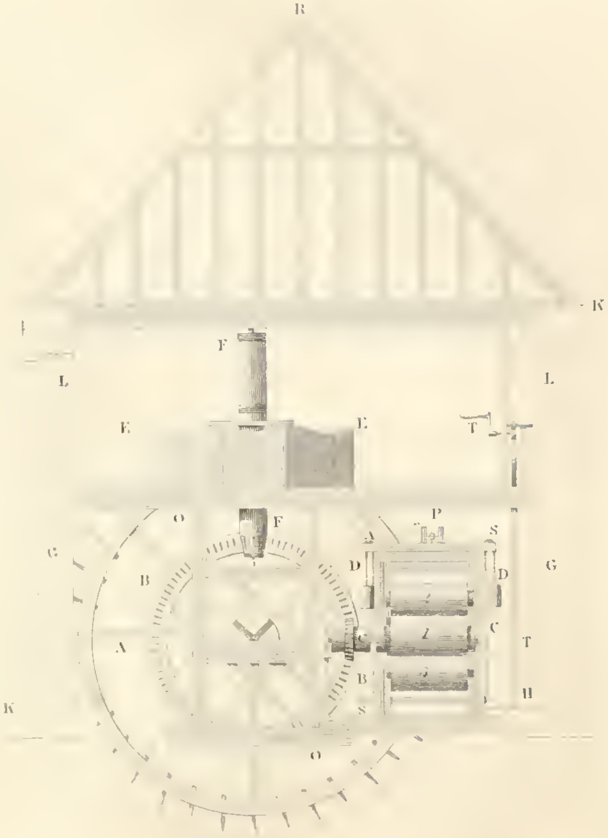




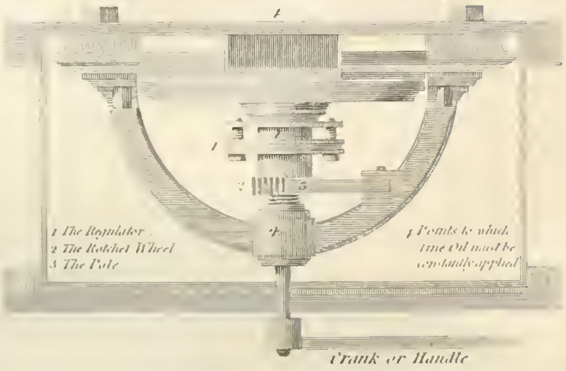


Double Flour Mill.

Flax Mill.



Patent Portable Corn Mill.



must be taken up, and both stones new drest with chisel and hammer; and every time the stone is taken up, there must be some tallow put round the spindle upon the bush, which will soon be melted by the heat the spindle acquires from its turning and rubbing against the bush, and so will get in betwixt them, otherwise the bush would take fire very soon.

The bush must embrace the spindle quite close, to prevent any shake in the motion, which would make some parts of the stones grate and fire against each other, whilst the other parts of them would be too far asunder, and by that means spoil the meal. Whenever the spindle wears the bush, so as to begin to shake in it, the stone must be taken up, and a chisel driven into several parts of the bush; and when it is taken out, wooden wedges must be forced into the holes, by which means the bush will be made to embrace the spindle again, close all round. In doing this, great care must be taken to drive equal wedges into the bush on opposite sides of the spindle, otherwise it will be thrown out of the perpendicular, and so hinder the upper stone from being set parallel to the under one, which is absolutely necessary for making good work. When any accident of this kind happens, the perpendicular position of the spindle must be restored by adjusting the bridge-tree with proper wedges between the brayer and it.

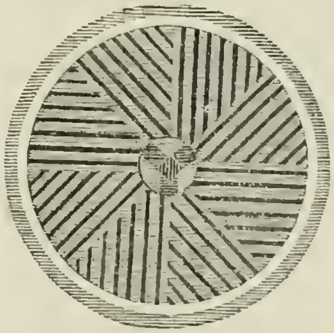
It frequently occurs, that the rynd is a little wrenched in laying down the upper stone upon it, or is made to sink a little lower on one side of the spindle than on the other, and this will cause one edge of the upper stone to drag all round upon the other, while the opposite edge will not touch. But this is easily set to rights, by raising the stone a little with a lever, and putting bits of paper, cards, or thin chips, between the rynd and the stone.

A less quantity of water will turn an overshot mill (where the wheel has buckets instead of float-boards) than a breast-mill, where the fall of water seldom exceeds half the height of the wheel; so that where there is but a small quantity of water, and a fall great enough for the wheel to lie under it, the bucket, or overshot wheel, is always used; but where there is a large body of water with a little fall, the breast, or float-board wheel, must be used. Where the water runs only upon a small declivity, it can act but slowly upon the under part of the wheel; in which case, the motion of the wheel will be slow, and therefore the floats ought to be very long, though not high, that a large body of water may act upon them, so that what is wanting in velocity may be made up in power; and then the cog-wheel may have a greater number of cogs, in proportion to the rounds in the trundle, in order to give the millstone a sufficient degree of velocity.

It was the opinion of Smeaton, that the powers necessary to produce the same effect on an undershot wheel, a breast-wheel, and an overshot wheel, must be to each other as the numbers 2·4, 1·75, and 1. For the float-board of a river mill is impelled, not by the velocity of the stream, but only by the excess of this above the velocity of the board itself. In the undershot wheel a great loss of power is occasioned by the accumulation of dead water, or of the water which having impinged against the float-board, remains nearly stagnant, and therefore impedes the advance of the next float-board.

In the Plate of *Mills*, we have given a section of a DOUBLE FLOUR MILL, of which A A is the water wheel; B B the shaft or axle; C C a wheel fixed upon the same axle, containing 90 teeth, or cogs, to drive the pinion; No. 1 having 23 teeth, which is fastened upon the vertical shaft D. No. 2, a wheel fixed upon the shaft D, containing 82 teeth, to turn the two pinions F, F, having 15 teeth, which are fastened upon the iron axles or spindles that carry the two upper millstones. E E, the beam or sill that supports the frame on which the under millstones are laid. G G, the cases or boxes that enclose the upper millstones; they should be about two inches distant from the stone all round its circumference. T T, the bearers, called *bridges*, upon which the under end of the iron spindles turn. These spindles pass upward through a hole in the middle of the nether millstones, in which is fixed a wooden bush that their upper ends turn in. The top part of the spindles above each wooden bush, is made square, and goes into a square hole in an iron cross, which is admitted into grooves in the middle and under surface of the upper millstone. By this means that stone is carried round along with the trundles F F, when turned by the wheel No. 2. One end of the bridges T T, is put into mortises in fixed bearers, and the other end into mortises in the bearers that move at one end on iron bolts, their other ends hanging by iron rods having screwed nuts, as U U, so that when turned forward or backward, they raise or depress the upper millstones, according as the miller finds it necessary. S S, the feeders, in the under end of each of which is a square socket that goes upon the square of the spindles above the iron cross or rynd, and having three or four branches that move the spout or shoe, and feed the wheat constantly from the hoppers into the hole or eye of the upper millstone, where it is introduced betwixt the stones, and by the circular motion of the upper stone acquires a centrifugal force; and proceeding gradually from the eye of the millstone towards the circumference, is at length thrown out in flour or meal. R R, the sluice, machine, and handle, to raise the sluice, and let the water on the wheel A to drive it round. No. 3 is a wheel fixed upon the shaft D, containing 44 teeth, to turn the pinion No. 4, having 15 teeth, which is fastened upon the horizontal axle H. On this axle is also fixed the barrel K, on which go the two leather belts that turn the wire engine and bolting mill. L, an iron spindle, in the under end of which is a square socket that takes in a square on the top of the gudgeon of the vertical shaft D. There is a pinion M, of 9 teeth, fixed on the upper end of the spindle L, to turn the wheel M M, having 48 teeth, which is fastened upon the axle round which the rope Z Z rolls, to carry the sacks of flour up to the cooling benches. By pulling the cord O O a little, the wheel M M and its axle are put into motion, in consequence of that wheel and its axle being moved horizontally, until the teeth of the wheel are brought into contact with those of the pinion at the top of the spindle L; and on the contrary, by pulling the cord P P, the wheel M and its axle are moved in the opposite horizontal direction, till they are thrown out of geer with the pinion, and the rotatory motion of that wheel stops. But when the sack of flour is raised up to the lever Q, it pushes up that end of the lever, and of course the other end down; by which means the pinion M is disengaged, and thus that part of the machine stops of itself. N N are two large hoppers, into which the clean wheat is put to be conveyed down to the hoppers S S, placed on the frame immediately above the millstones. W W, the side wall of the millhouse. V, the couples or frame of the roof. X X, windows to lighten the house.

UNDER-MILLSTONE.—*Fig.* 1.



UPPER-MILLSTONE.—*Fig.* 2.

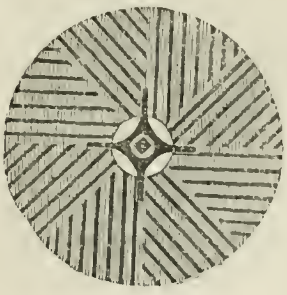


Fig. 1, is a correct representation of the surface of the under grinding millstone; the way of laying out the roads or channels; the wooden bush fixed into the hole in its middle, in which the upper end of the iron spindle turns round; and the case or hoops that surround the upper one, which ought to be two inches clear of the stone all round its circumference. Fig. 2, is the upper grinding millstone, with an iron cross or rynd in its middle; in the centre of which is a square hose that takes in a square on the top of the iron spindle, to carry round the millstone. When the working sides or faces of the millstones are laid uppermost, the roads (or channels) must lie in the same direction in both; so that when the upper stone is turned over, and its surface laid upon the under one, then the channels may cross each other, which assists in grinding and throwing out the flour; the sharp edges of the two furrows then cutting against each other like scissors. The roads are likewise laid out according to the way the upper stone revolves. In those represented in the figures the running millstone is supposed to turn '*sun-way*,' or as in what is called a *right-handed* mill; but if the stone revolves the other way, the channels must be reversed, and then the mill is termed a *left-handed* one.

When the diameter of the upper stone is about 6 feet, as is generally the case, the lower is about an inch more; the upper stone then contains about 22½ cubic feet, and weighs rather more than 19,000 pounds. A stone of this kind ought never to revolve more than 60 or 70 times in a minute; for a more rapid motion would heat the meal. Nor must the water wheel be too large, for in that case its angular motion will be too slow; on the contrary, if the wheel be too small, it will be deficient in moving power; 18 feet diameter is recommended as a proper medium. Ferguson, on the supposition that the floats of the wheel ought to move with a third part of the velocity of the water—a supposition, however, not strictly consistent either with theory, or with Smeaton's experiments—gives the following rules for constructing the chief parts of the mill.

1. Measure the perpendicular height of the fall of water in feet above that part of the wheel on which the water begins to act, and call that the height of the fall. 2. Multiply this constant number 64·2882 (or rather 64⅓) by the height of the fall in feet, and extract the square root of the product, which will be the velocity of the water at the bottom of the fall, or the number of feet the water moves per second. 3. Divide the velocity of the water by 3, and the quotient will be the velocity of the floats of the wheel in feet per second. 4. Divide the circumference of the wheel in feet, by the velocity of its floats, and the quotient will be the number of seconds in one turn or revolution of the great water wheel, on the axis of which is fixed the cog wheel that turns the trundle. 5. Divide 60 by the number of seconds in one turn of the water wheel or cog-wheel, and the quotient will be the number of turns of either of these wheels in a minute. 6. Divide 60 (the number of turns the millstone ought to have in a minute) by the abovesaid number of turns, and the quotient will be the number of turns the millstone ought to have for one turn of the water or cog wheel. Then, 7. As the required number of turns of the millstone in a minute is to the number of turns of the cog wheel in a minute, so must the number of cogs in the wheel be to the number of staves or rounds in the trundle on the axis of the millstone, in the nearest whole number that can be found.—By these rules the following table is calculated, in which the diameter of the water wheel is supposed 18 feet, and consequently its circumference $56\frac{4}{7}$.

THE MILLWRIGHT'S TABLE.

Perpendicular height of the fall of water.	*Velocity of the water in feet per second.*	*Velocity of the wheel in feet per second.*	*No. of turns of the wheel in a minute.*	*Required number of turns of the millstone for each turn of the wheel.*	*Nearest No. of cogs and staves for that purpose.* Cogs.	Staves.	*Number of turns of the millstone for one turn of the wheel by these cogs and staves.*	*Number of turns of the millstone in a minute by these cogs and staves.*
1	8·02	2·67	2·83	21·20	127	6	24·17	59·91
2	11·40	3·78	4·00	15·00	105	7	15·00	60·00
3	13·89	4·63	4·91	12·22	98	8	12·25	60·14
4	16·04	5·35	5·67	10·58	95	9	10·56	59·87
5	17·93	5·98	6·34	9·46	85	9	9·44	59·84
6	19·64	6·55	6·94	8·64	78	9	8·66	60·10
7	21·21	7·07	7·50	8·00	72	9	8·00	60·00
8	22·68	7·56	8·02	7·48	67	9	7·44	59·67
9	24·05	8·02	8·51	7·05	70	10	7·00	59·57
10	25·35	8·45	8·97	6·69	67	10	6·70	60·09
11	26·59	8·86	9·40	6·38	64	10	3·40	60·16
12	27·77	9·26	9·82	6·11	61	10	6·10	59·90
13	28·91	9·64	10·22	5·87	59	10	5·80	60·18
14	30·00	10·00	10·60	5·66	56	10	5·60	59·36
15	31·05	10·35	10·99	5·46	55	10	5·40	60·18
16	32·07	10·69	11·34	5·29	53	10	5·30	60·10
17	33·06	11·02	11·70	5·13	51	10	5·10	59·67
18	34·02	11·34	12·02	4·99	50	10	5·00	60·10
19	34·95	11·65	12·37	4·85	49	10	4·80	60·61
20	35·86	11·92	12·68	4·73	47	10	4·70	59·59

Fenwick's experiments on some of the best mills for grinding corn, were undertaken to form the following tables, illustrative of the effect of a given quantity of water, in a given time, applied to an *overshot* water wheel of a given size. The millstones were from 4½ to 5 feet diameter, and made from 90 to 100 revolutions per minute. And the result was, that the power requisite to raise a weight of 300 lbs. avoirdupoise, with a velocity of 190 feet a minute, would grind one boll of good rye in an hour; but to avoid imperfections, it is taken, for practice, at 300 lbs. raised with a velocity of 210 feet per minute (being one-tenth more); and for grinding 2, 3, 4, or 5, bolls of rye per hour, requires a power = 300 lbs. raised with the velocity of 350, 506, 677, or 865 feet a minute respectively.

The difference of the power requisite to grind equal quantities of wheat from that for rye, is very trifling. The boll is four bushels Winchester measure; two bolls are therefore one quarter. The power necessary to raise a weight of 300 lbs. avoirdupoise, with a velocity of 390 feet per minute, will properly prepare one ton of old rope per week, for the purpose of making paper; and for grinding down in like manner two tons of the same material in a week, we should want a power able to raise 300 lbs. with a velocity of 525 feet in a minute, to work the mill 12 hours daily.

TABLES, *shewing the Quantity of Water (Ale Measure) requisite to grind different quantities of Corn, from 1 to 5 Bolls (Winchester Measure) per hour, applied to overshot Water-Wheels, from 10 to 32 feet diameter; also the size of the Cylinder of the common Steam-Engine to do the same work.*

The water-wheel 10 feet diam.

Bolls of corn ground per hour.	Quantity of water requisite, in ale gallons, per minute.	Diam. in inches of the cylinder of a steam-engine to do the same work.
1	786	12·5
1½	1056	14·6
2	1341	16·75
2½	1617	18·5
3	1894	20·2
3½	2220	21·75
4	2541	23·25
4½	2891	24·75
5	3242	26·25

The water-wheel, 12 feet diam.

Bolls per hour.	Water, gallons per minute.	Cylinder, in inches.
1	655	12·5
1½	873	14·6
2	1091	16·75
2½	1343	18·5
3	1576	20·2
3½	1840	21·75
4	2117	23·25
4½	2408	24·75
5	2700	26·25

The water-wheel, 14 feet diam.

Bolls per hour.	Water, gallons per minute.	Cylinder, in inches.
1	564	12·5
1½	740	14·6
2	927	16·75
2½	1140	18·5
3	1353	20·2
3½	1583	21·75
4	1811	23·25
4½	2060	24·75
5	2306	26·25

The water-wheel, 16 feet diam.

Bolls of corn ground per hour.	Quantity of water requisite, in ale gallons, per minute.	Diam. in inches of the cylinder of a steam-engine to do the same work.
1	491	12·5
1½	650	14·6
2	811	16·75
2½	993	18·5
3	1176	20·2
3½	1380	21·75
4	1582	23·25
4½	1802	24·75
5	2023	26·25

The water-wheel, 18 feet diam.

Bolls per hour.	Water, gallons per minute.	Cylinder, in inches.
1	440	12·5
1½	595	14·6
2	730	16·75
2½	860	18·5
3	1054	20·2
3½	1227	21·75
4	1400	23·25
4½	1600	24·75
5	1800	26·25

The water-wheel, 20 feet diam.

Bolls per hour.	Water, gallons per minute.	Cylinder, in inches.
1	392	12·5
1½	530	14·6
2	675	16·75
2½	808	18·5
3	945	20·2
3½	1110	21·75
4	1270	23·25
4½	1445	24·75
5	1623	26·25

The water-wheel, 22 feet diam.

Bolls per hour.	Water, gallons per minute.	Cylinder, in inches.
1	350	12·5
1½	473	14·6
2	594	16·75
2½	722	18·5
3	860	20·2
3½	1007	21·75
4	1153	23·25
4½	1313	24·75
5	1472	26·25

The water-wheel, 24 feet diam.

Bolls per hour.	Water, gallons per minute.	Cylinder, in inches.
1	327	12·5
1½	436	14·6
2	545	16·75
2½	671	18·5
3	788	20·2
3½	920	21·75
4	1055	23·25
4½	1204	24·75
5	1350	26·25

The water-wheel, 26 feet diam.

Bolls per hour.	Water, gallons per minute.	Cylinder, in inches.
1	303	12·5
1½	403	14·6
2	504	16·75
2½	617	18·5
3	730	20·2
3½	852	21·75
4	975	23·25
4½	1111	24·75
5	1247	26·25

The water-wheel, 28 feet diam.

Bolls per hour.	Water, gallons per minute.	Cylinder, in inches.
1	282	12·5
1½	370	14·6
2	463	16·75
2½	570	18·5
3	676	20·2
3½	791	21·75
4	905	23·25
4½	1030	21·75
5	1153	26·25

The water-wheel, 30 feet diam.

Bolls per hour.	Water, gallons per minute.	Cylinder, in inches.
1	267	12·5
1½	355	14·6
2	447	16·75
2½	545	18 5
3	645	20·2
3½	750	21·75
4	858	23·25
4½	983	24·75
5	1106	26·25

The water wheel, 32 feet diam.

Bolls per hour.	Water, gallons per minute.	Cylinder, in inches.
1	245	12·5
1½	325	14·6
2	406	16·75
2½	496	18·5
3	588	20·2
3½	690	21·75
4	791	23·25
4½	900	24·75
5	1012	26·25

A Rule to make the foregoing Table applicable to Mills intended to be turned by undershot or breast Water-wheels.—The power required on an undershot water-wheel, to produce an effect equal to that of an overshot, (to which the tables are applicable,) is as 2·4 to 1; and also the power required on a breast water-wheel, which receives the water on some point of its circumference, and afterwards descends on the ladle boards, to produce an equal effect with an overshot water-wheel, is as 1·75 to 1.

TABLE, *shewing the necessary Size of the Cylinder of a common Steam-Engine to grind different quantities of Corn, from* 1 *to* 12 *Bolls (*4 *to* 48 *Bushels, Winchester Measure) per hour.*

Bolls of Corn ground per hour.	Diameter of the Cylinder in Inches.	Bolls of Corn ground per hour.	Diameter of the Cylinder In Inches.
1	12.3	7	29·8
1½	14·6	7½	31·1
2	16·75	8	32
2½	18·5	8½	33·3
3	20·2	9	34·2
3½	21·75	9½	35·2
4	23·25	10	36
4½	24·75	10½	37·3
6	26·25	11	38
5½	27·25	11½	38·85
6	28·1	12	39·5
6½	29		

N. B. This table will be applicable to any improved steam-engine, as well as that of the common kind, if the ratio of their efficacies is known.

The Application of the foregoing Tables. *Example* 1. If a stream of water, producing 808 gallons, ale measure, per minute, can be applied on an overshot water-wheel 20 feet diameter, what quantity of corn will it be able to grind per hour?—Look in the tables under a 20 feet water-wheel, and opposite 808 gallons will be found 2½ bolls of corn ground per hour.

2. If a stream of water, producing 808 gallons, ale measure, per minute, can be applied to an undershot water-wheel 20 feet diameter, what quantity of corn can it grind per hour?—It is found by the tables, that if applied on an overshot water-wheel 20 feet diameter, the stream will grind 2½ bolls per hour; and from the rule preceding the last table, the power required by the undershot to that of the overshot water-wheel, to produce an equal effect, being as 2·4 to 1, therefore, as 2·4 : 1 : : 2·5 : 1·04 bolls of corn ground per hour by means of the stream.

3. If a stream of water, producing 808 gallons, ale measure, per minute, can be applied on a breast water-wheel 20 feet diameter, what quantity of corn can it grind per hour!—It is found by the tables, that if applied on an overshot water wheel of equal size, 2½ bolls of corn will be ground per hour; and from the rule above, the power of a breast water-wheel to that of an overshot water-wheel, to produce an equal effect, is as 1·75 to 1, therefore, as 1·75 : 1 : : 2·5 : 1·42 bolls of corn ground per hour by the stream.

4. Of what diameter must the cylinder of a common steam-engine be made, to grind 10 bolls of corn per hour?—By looking in the foregoing table, opposite 10 bolls ground per hour, the diameter of the steam cylinder will be found to be 86 inches.

FLOWER, FLOS, the most beautiful part of trees and plants, containing the organs or parts of fructification. The method of preserving flowers in their natural beauty has been much sought after. The following method does well:—Gather the flowers when they are not thoroughly open, in the middle of a dry day, put them into a glazed earthen vessel; fill this to the top with them, and when full, sprinkle them over with some French wine, with a little salt in it; then set them by in a cellar, tying down the mouth of the pot. After this they may be taken out at pleasure; and on setting them in the sun, or within the reach of the fire, they will open as if growing naturally; and not only the colour, but the odour also, will be preserved. Most persons can try and verify this experiment.

FLOWER DE LIS, or *Flower de Luce*, in Heraldry, a bearing representing the lily, called the queen of flowers, and the true hieroglyphic of majesty.

FLOWING, the position of the sheets or lower corners of the principal sails when they are loosened to the wind, so as to receive it more nearly perpendicular than when they are close hauled, although more obliquely than when going before the wind; a ship is therefore said to have a flowing sheet, when the wind crosses the line of her course nearly at right angles, that is to say, a ship steering due north with the wind at the east, or directly on her side, will have a flowing sheet; whereas if the sheets were extended close aft, she would sail two points nearer the wind, *viz.* N. N. E.

FLUATS, in Chemistry, salts first discovered by Scheele, and distinguished by the following properties. When sulphuric acid is poured upon them they emit acrid vapours of fluoric acid, which corrode glass. When heated, several of them phosphoresce. They are not decomposed by heat, nor altered by combustibles. They combine with silica by means of heat. Most of them are sparingly soluble in water.

FLUENT, in Fluxions, the flowing quantity, or that which is continually increasing or decreasing.

FLUID, or FLUID BODY, is that whose parts yield to the smallest force impressed upon them, and which by yielding are easily moved amongst each other; in this sense a fluid stands opposed to a solid, whose parts do not yield, but constantly maintain the same relative situation. The fluidity of bodies is accounted for by supposing them made up of infinitely small particles, possessing, with regard to each other, an attractive and repulsive power, which being equal, places the whole system in equilibrium, whereby it obeys any external force impressed upon it. This hypothesis evidently places the several particles of a fluid at small distances from each other, and consequently supposes them to be porous, or to possess certain vacuities, the existence of which may be demonstrated from various experiments. Thus, water will dissolve a certain quantity of salt; after which it will absorb a little sugar, and after that a little alum; and all this without increasing its bulk: which evidently shews, that the particles of these solids are so far separated as to become smaller than the vacuities, or interstices, between the particles of the fluid or water.

Fluids are divided into *Elastic* and *Non-elastic*. *Elastic* Fluids, are those which may be compressed into a smaller compass, but which, on removing the pressure, resume again their former dimensions; as air, and the various gases. *Non-elastic* Fluids, are those which occupy the same bulk under all pressures, or, if they be at all compressible, it is in a very trifling degree; such as water and other liquids.

FLUOR. This spar may be divided into three species, compact, foliated, and earthy. The second species is most abundant, and is usually called in England, Derbyshire spar. Berzelius found its constituents to be 72·1 lime, and 27·9 fluoric acid. It is cut into a variety of ornamental forms. When two pieces are rubbed together in the dark, they phosphoresce with a blue and green light. Sulphuric acid evolves flouric fumes which corrode glass.

FLUORIC Acid, is found in combination with calcareous earth, in Derbyshire spar. If the pure spar be placed in a retort of lead or silver, with a receiver of the same metal adapted, and its weight of sulphuric acid be then poured upon it, the fluoric acid will be disengaged with a moderate heat. This acid readidly combines with water, for which purpose it is necessary that the receiver should be previously half filled with that fluid. This acid attacks glass, and corrodes it; and it has been employed in etching figures on glass: the whole glass must be covered with a thin coating of wax, in which the figure is to be traced, so as to leave bare the parts intended to be acted upon. This acid consists of oxygen, and its base fluor.

FLUORINE, in Chemistry, a substance that has never yet been detected in an uncombined state. There is reason, however, to believe it is an elementary substance. With hydrogen it forms fluoric acid. Combined with fluor it forms the fluoric acid.

FLURRY, a light breeze of wind shifting to different places, and causing a little ruffling on the calm surface of the sea.

FLUTE, Fistula, wind, an instrument of music. The tones or notes are changed by stopping and opening the holes disposed for that purpose along its side. The ancient fistulæ, or flutes, were made of reeds, afterwards of wood, and last of metal. Flutes are now sometimes made of glass.

Flute, *German*, is an instrument different from the common flute; instead of being put into the mouth to be played, the end is stopt with a plug, and the lower lip is applied to a hole about two inches and a half, or three inches, distant from the end. It is perforated with holes, the lowest of which is stopped and opened by the little finger's pressing on a brass or silver key.

Flutes, or *Flutings*, in Architecture, perpendicular channels, or cavities, cut along the shaft of a column or pilaster.

FLUX, in Metallurgy, is sometimes used synonymously with fusion; for instance, an ore, or rather matter, is said be in liquid flux when it is completely fused. But the word flux is generally used to signify certain saline matters, which facilitate the fusion of ores, and other substances which are not easily fusible in assays, and in the reduction of ores. In the large way, limestone and fusible spar are used as fluxes. The fluxes used in assays, or philosophical experiments, consist usually of alkalies, which render the earthy mixtures fusible, by converting them into glass; or else glass itself in powder. Alkaline fluxes are either the crude flux, the white flux, or the black flux. Crude flux is a mixture of nitre and tartar, which are put into the crucible with the mineral intended to be fused. The detonation of the nitre with the inflammable matter of the tartar, is of service in some operations; though generally it is attended with inconvenience on account of the swelling of the materials, which may throw them out of the vessel, if proper care be not taken either to supply only a little of the mixture at a time, or to procure a large vessel. White flux is formed by projecting equal parts of a mixture of nitre and tartar, by moderate portions at a time, into an ignited crucible. In the detonation which ensues, the nitric acid is decomposed, and flies off with the tartaric acid, and the remainder consists of the potash in a state of considerable purity. This has been called fixed nitre. Black flux differs from the preceding, in the proportion of its ingredients. In this the weight of the tartar is double that of the nitre; on which account the combustion is incomplete, and a considerable portion of the tartaric acid is decomposed by the mere heat, and leaves a quantity of coal behind, on which the black colour depends. It is used where it is intended to reduce metallic ores, and effects it by uniting with the oxygen of the oxide.

Flux, in Medicine, an extraordinary issue, or evacuation, of some humours of the body.

FLUXION, in the Newtonian Analysis, denotes the velocity with which a flowing quantity increases by its generative motion, by which it stands contradistinguished from a fluent, or flowing quantity, which is constantly and indefinitely increasing, after the manner that a surface is described by the motion of a line, or a solid by the motion of a surface. Or a fluxion may be otherwise defined, as the magnitude by which any flowing quantity would be uniformly increased in a given portion of time, with the generating celerity at any proposed position or instant, supposing it thence to continue invariable.

Fluxional Analysis, is the algorithm, or analysis of fluxions and flowing quantities, distinguishable from the differential calculus both by its metaphysics and notation, but in all other respects the two methods are identical.

The invention of the fluxional analysis does more honour to the powers of the human mind, than perhaps any discovery of this or any preceding age; it opens to us a new world, and extends our knowledge as it were to infinity; it carries us beyond those bounds which seem prescribed to our mental powers, and leads to investigations and results which must otherwise have for ever remained in impenetrable obscurity. And without entering into all the proofs we could adduce in support of our assertion, we ascribe the glory of this invention to Sir Isaac Newton, though it has been also claimed on the continent for Leibnitz. But as we do not intend to enter upon this subject here, the reader will not expect a minute detail of the principle of fluxions. It will be sufficient to observe, that all finite magnitudes are here conceived to be resolved into infinitely small ones, supposed to be generated by motion, as a line by the motion of a point, a superficies by a line, and a solid by a superficies; of which they are the elements, moments, or differences. The art of finding these infinitely small quantities, or the velocities by which they are generated, and of working on them, and discovering other infinite quantities by their means, makes what is called the *Direct Method of Fluxions*. And the method of finding the fluents or flowing quantities, these fluxions being given, is what constitutes the *Inverse Method*.

What renders the knowledge of infinitely small quantities of such great use and extent is, that they have relations to each other, which the finite magnitudes, whereof they are the infinitesimals, have not. Thus for example, in a curve of any kind whatever, the infinitely small differences of the ordinate and absciss have the ratio to each other, not of the ordinate and absciss, but of the ordinate and subtangent; and of consequence, the absciss and ordinate being known, will give the subtangent; or, which amounts to the same, the tangent itself.

Notation.—The method of notation in fluxions, introduced by the inventor, Sir Isaac Newton, is as follows:—The variable, or flowing quantity, to be uniformly augmented, as suppose the absciss of a curve, he denotes by the final letters v, x, y, z; and their fluxions by the same letters with dots placed over them, thus, $\dot{v}$, $\dot{x}$, $\dot{y}$, $\dot{z}$. And the initial letters, a, b, c, d, &c. are used to express invariable quantities.

Again, if the fluxions themselves are also variable quantities, and are continually increasing or decreasing, he considers the velocities with which they increase or decrease, as the fluxions of the former fluxions or second fluxions, which are denoted by two dots over them, thus, $\ddot{y}\ \ddot{x}\ \ddot{z}$.

After the same manner, one may consider the increase and diminution of these, as their fluxions also, and thus proceed to the third, fourth, &c. fluxions, which will be denoted thus,

$\overline{\dddot{y}\,\dddot{x}\,\dddot{z} : \ddddot{y}}\,\ddddot{x}\,\ddddot{z}$. Lastly, if the flowing quantity be a surd, as $\sqrt{x - y}$, he denotes its fluxion by $(\sqrt{x-y})^{\cdot}$; if a fraction $\frac{x\,x}{d-y}$ it is denoted by $\left(\frac{x\,x}{d-y}\right)^{\cdot}$ Sometimes, however, the fluxions of compound quantities are expressed by placing the Letter F, or f before them, thus, instead of $\left(\sqrt{(x-y)}\right)^{\cdot}$, is written F. $\sqrt{(x-y)}$ or $f.\sqrt{(x-y)}$. We shall, however, in the following article, denote the fluxion by F, and the fluent by $f.$; so that,

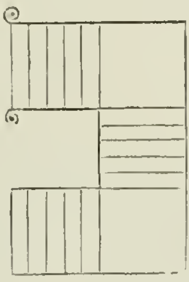
$$\left.\begin{array}{l} \text{F. } \sqrt{(x-y)} \\ \text{F. } \dfrac{x + a\,x^2}{b + x} \end{array}\right\} \text{denote the fluxions of} \left\{\begin{array}{c} \sqrt{(x-y)} \\ \dfrac{x + a\,x^2}{b+x} \end{array}\right.$$

$$\left.\begin{array}{l} f.\ x\,\sqrt{(x + a\,x^2)} \\ f.\ \dfrac{\dot{x}\,b}{x + a\,x^2} \end{array}\right\} \text{denote the fluents of} \left\{\begin{array}{c} \dot{x}\,\sqrt{(x + a\,x^2)} \\ \dfrac{b\,\dot{x}}{x + a\,x^2} \end{array}\right.$$

FLY, is a name given to a certain appendage to many machines, either as a *regulator* of their motions, or as a *collector* of power. When used as a regulator, the fly is commonly a heavy disk or hoop balanced on its axis of motion, and at right angles to it; though sometimes a regulating fly consists of vanes or wings, which, as they are whirled round, meet with considerable resistance from the air, and thus soon prevent any acceleration in the motion; but this kind of regulator should rarely, if ever, be introduced in a working machine, as it wastes much of the moving force. When the fly is used as a collector of power, it is frequently seen in the form of heavy knobs at the opposite ends of the straight bar, as in the coining press.

Fly *of an Ensign, Pendant*, &c. the breadth or extent from the staff to the extreme edge or end that flutters loose in the wind.

Fly *Boat*, or *Flight*, a large flat-bottomed Dutch vessel, whose burden is generally from 4 to 600 tons: it is distinguished by a stern remarkably high, and by very broad buttocks below.



FLYERS, in Architecture, such stairs as go straight, and do not wind round, or have the steps made tapering; but the fore and back part of each stair, and the ends respectively parallel to one another, as in the annexed figure. So that if one flight do not carry you to your designed height, there is a broad half space; and then you fly again, with steps as before, every where of the same breadth and length as in the diagram.

FLYING Pinion, is part of a clock, having a fly, to gather air, and restrain the rapidity of the clock's motion.

FLYING, the progressive motion of a bird, or other winged animal, in the liquid air. The parts of birds chiefly concerned in flying, are the wings, by which they are sustained or wafted along. The manner of flying is thus:—The bird first bends his legs, and springs with a violent leap from the ground, then opens and expands the joints of its wings, so as to make a right line perpendicular to the sides of his body; thus the wings, with all the feathers therein, constitute one continued lamina. Being now raised a little above the horizon, and vibrating the wings with great force and velocity perpendicularly against the subject air, that fluid resists those succussions, both from its natural inactivity and elasticity, by means of which the whole body of the bird is protruded. The resistance the air makes to the withdrawing of the wings, and consequently the progress of the bird, will be so much the greater, as the waft or stroke of the fan of the wing is longer.

FOCUS, in Optics, is a point wherein several rays concur, or are collected, after having undergone either refraction or reflection. This point is thus denominated, because the rays being here brought together and united, their joint effect is sufficient to burn bodies exposed to their action; and hence this point is called the *focus*, or burning point. It must be observed, however, that the focus is not, strictly speaking, a point; for the rays are not accurately collected into one and the same place or point; owing to the different nature and refrangibility of the rays of light, to the imperfections in the figure of the lens, and other similiar impediments. The focus, therefore, is a small circle which Huygens has demonstrated to be one-eighth the thickness of the lens, when it is convex on both sides; that is, it cannot be less than this, but in imperfect glasses it exceeds the above measure sometimes considerably.

Virtual Focus, or *Point* of *Divergence*, so called by Mr. Molyneux, is the point from which rays tend after refraction or reflection; being in this respect opposed to the ordinary focus, or point of concurrence, where rays are made to meet after refraction or reflection. Thus, the foci of an hyperbola are mutually virtual foci to each other; but in an ellipse, they are common foci to each other; for the rays are reflected from the other focus in the hyperbola, but towards it in the ellipse.

Practical Rules for finding the Foci of Glasses.— 1. To find by experiment, the focus of a convex spherical glass, being of a small sphere; apply it to the end of a scale of inches and decimal parts, of a convenient length, and expose it before the sun; upon the scale may be seen the brigth intersection of the rays measured out: or, expose it in the whole of a dark chamber; and where a white paper receives the distinct representation of distant objects, there is the focus of the glasses. 2. For a glass of a pretty long focus, observe some distant object through it, and recede from the glass till the eye perceives all in confusion, or the object begins to appear inverted; then the eye is in the focus. 3. For a plano-convex glass; make it reflect the sun against the wall; on the wall will then be seen two sorts of light, a brighter within another more obscure; withdraw the glass from the wall, till the bright image be in its least dimensions; then is the glass distant from the wall about a fourth part of its focal length. 4. For a double convex; expose each side to the sun in like manner; and observe both the distances of the glass from the wall: then is the first distance about half the radius of the convexity turned from the sun; and the second is about half the radius of the other convexity. The radii of the two convexities being thus known, the focus is then found by this rule: As the sum of the radii of both convexities is to the radius of either convexity, so is double the radius of the other convexity to the distance of the focus.

FODDER, or **Fother**, in Mining, a measure containing twenty-two hundred and a half weight, as of lead, but in London it is twenty hundred.

FŒTUS, in Anatomy, a term applied to the offspring of the human subject, or of animals, during its residence in the womb.

FOG, or **Mist**, consisting of condensed vapours floating near the surface of the earth.

Fog *Bank*, an appearance in hazy weather which frequently resembles land at a distance, but which vanishes as you approach it.

FOIL, in Fencing, a blunt sword, or one tipped with a button or cork, covered with leather. Foils are used in the noble and manly exercise of fencing.

Tin **Foil**, among Jewellers, is used to give precious stones a colour, by placing it beneath the gem; and this species of foil is manufactured from copper, silver, or gold. The copper foils are known as *Nuremberg* or German foils, and are prepared as follows:—Procure the thinnest copper, beat it on an anvil with a well polished hammer, as thin as possible; place the copper between two iron plates as thin as writing paper; heat them in the fire; then boil the foil in a pipkin, with equal quantities of tartar and salt, constantly stirring them till by boiling they become white; after which take them out and dry them; then give them another hammering, till they are made fit for your purpose. If too much heated they will melt; if too long boiled, they will attract the salt. Polish them thus:—Take a plate of the best copper 12 inches long, 5 inches broad, polished to the greatest perfection; bend this to a long convex, fasten it upon half a roll, and fix to it a bench or table; then take some chalk washed as clean as possible, and filtered through a fine clean linen cloth; lay some of this on the roll, wet the copper all over, lay the foils on it, and with a polishing stone and the chalk, polish your foils till they are as bright as a looking-glass after which they must be dried, and laid up free from dust.

FOLIATING or **Silvering** of *Looking-Glasses*, is spreading the plates over, after they are polished, with amalgam, to reflect the image. The process is as follows:—A thin blotting paper is spread on the table, and sprinkled with chalk; then a fine leaf of tin-foil is laid over the paper; upon this mercury is poured, and distributed equally over the leaf with a hare's foot, or cotton: over this is laid a clean paper, and over that the glass plate, which is pressed down with the right hand, and the paper drawn out with the left; this done, the plate is covered with a thicker paper, and loaded with a greater weight, that the superfluous mercury may be driven out, and the tin adhere more closely to the glass. When dry, the weight is removed, and the looking-glass is complete. Some add an ounce of marcasite, melted by the fire; and lest the mercury should evaporate in smoke, pour it into cold water; and when cooled, squeeze it through a cloth or leather.

Foliating of *Globe Looking-Glasses.* Take five ounces of quicksilver, and one ounce of bismuth; of lead and tin half an ounce each; put the lead and tin into fusion, then put in the bismuth, and when that is in fusion let it stand till it is almost cold, and pour the quicksilver into it; after this, take the glass globe, which must be very clean, make a paper funnel, which put into the hole of the globe, as near to the glass as you can, pour the amalgam in gently, and move it about, so that it may touch every where.

FOMALHAUT, or Fomahaut, a star of the first magnitude in Piscis Australis, marked α by Bayer.

FOMENTATION, in Medicine, is the external application of a fluid, as warm as the patient can bear it. Two flannel cloths are dipped in that liquor, one of which is wrung as dry as possible, and immediately applied to the part affected. This cloth lies on till the heat has evaporated, and the other is then applied. By this alternate application the part affected is constantly supplied with warmth, for 15 minutes, or half an hour, as occasion may require.

FOOD, *Comparative Nutritive Properties of.* An interesting report on this subject has lately been presented to the French minister of the interior, by Messrs. Percy and Vauquelin, members of the Institute. The result of their experiments is as follows:—In bread, every 100 lb. is found to contain 80 lb. of nutritious matter; butcher meat, averaging the different sorts, contain only 35 lb. in one hundred; French beans, (in the grain,) 92 lb. in one hundred; broad beans, 89 lb.; peas, 93 lb.; lentils, (a species of half pea, little known in Britain,) 94 lb. in one hundred; greens and turnips, which are the most aqueous of all vegetables used in culinary purposes, furnish only 8 lb. of solid nutritious substance in one hundred; carrots, (from whence an inferior kind of sugar is produced,) 14 lb.; and what is remarkable, as being opposed to the old theory, 100 lb. of potatoes only yield 25 lb. of nutriment; one pound of good bread is equal to 2½ lb. of potatoes; and 75 lb. of bread, and 30 lb. of meat, are equal to 300 of potatoes; ½ lb of bread, and 5 oz. of meat, are equal to 3 lb. of potatoes; 1 lb. of potatoes is equal to 4 lb. of cabbage, and 3 lb. of turnips; and one pound of rice bread or French beans is equal to 3 lb. of potatoes.

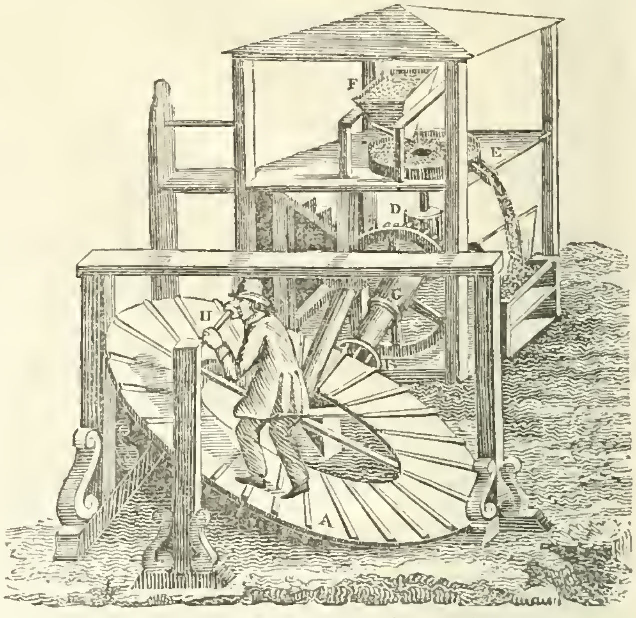
FOOT, a measure of length, derived from the length of the human foot; containing 12 linear inches. *Square* Foot, is a square whose side is one foot, and is therefore equal to 144 square inches. *Cubic* Foot, is a cube whose side is one foot, and the cube contains 1728 cubic inches.

Foot, in the Latin and Greek poetry, a metre or measure composed of a certain number of long and short syllables. These feet are commonly reckoned twenty-eight, of which some are simple, as consisting of two or three syllables, and therefore called dissyllabic or trisyllabic feet; others are compound, consisting of four syllables, and are therefore called tetrasyllabic feet.

Foot *of a Sail*, the lower edge, or bottom. *Foot Rope*, the rope to which the lower edge of a sail is sewed. *Foot Ropes* are also the same with *Horses of the Yards*, which see.

Foot *Waleing*, the whole inside planks or lining of a ship, used to prevent any part of her ballast or cargo from falling between her floor timbers. *Foot of a Mast*, the lowest end or that which goes into the step.

Foot *Mill*, or *Tread-Mill*, for grinding corn or other substances, moved by the pressure of the feet of men or animals. In some of these mills, a horse or an ox is fixed to a stall upon a floor above a vertical wheel, and a hole is made in the floor in the place where the hind feet of the animal should stand, thus admitting those feet to press upon the rim of a wheel, and cause the wheel to turn upon its axle, and give motion to the whole mill. But in this kind of machine, the animal will be obliged very unnaturally to move his hind feet, while his fore feet will be at rest; and further, the motive force being applied near the vertex of the wheel, will act but with little advantage, and the work done will be comparatively trifling. A much more judicious construction of a foot mill is represented in the above engraving. A, is an inclined wheel, which is turned by the weight of a man, and the impulsive force of his feet while he supports himself, or occasionally pushes with his hands at the horizontal bar H. The face of this wheel has thin pieces of wood nailed upon it at proper distances, to keep the feet of the man from slipping while he pushes the wheel round; and the under side has projecting teeth or waves which catch into the cogs of the trundle B, and by that means turn the horizontal shaft G, with its wheel C; this latter wheel turns the trundle D, the axle of which carries the upper millstone E. This kind of footmill will answer extremely well to grind malt, &c. when no very great power is required. And as respects the application of animal force to machinery, *see* pages 325 and 326, of this work, where this matter is treated in all its various relations, both to man and beasts of burden.



FORAGE, in Military affairs, denotes the provisions brought into the camp by the troops for the sustenance of the horses.

FORCE, in Mechanics, denotes that unknown cause which produces a change in the state of a body, as to motion, rest, pressure, &c.; that is, whatever produces or tends to produce motion, or a change of motion in any body, is called force. According to this definition, the muscular power of animals, as likewise pressure, impact, gravity, &c. are considered as forces, or sources of motion, it being evident, from daily experience, that bodies exposed to the free action of any of these, are either put into motion, or have their state of motion changed. All forces, however various, are measured by the effects they produce in like circumstances, whether the effect be creating, accelerating, retarding, or deflecting motions; the result of some general and commonly observed force is taken for unity, and with this any others may be compared; and their proportions represented by numbers or lines. Under this point of view they are considered by the mathematician; all else falls within the province of the universal philosopher, or the metaphysician. When we say that a force is represented by a right line, A B, it is to be understood that it would cause a material point, situated at rest in A, to run over the line A B, which is called the direction of the force, so as to arrive at B at the end of a given time, while another force would cause the same point to have moved a greater or less distance from A in the same time. *See* the figure below.

Mechanical forces may be reduced to two sorts; one of a body at rest, the other of a body in motion. The former is that which we conceive as residing in a body when it is supported by a plane, suspended by a rope, or balanced by the action of a spring, &c. being denominated pressure, tension, force, or *vis mortua*, *solicitatio*, *conatus movendi*, and which may always be estimated or measured by a weight, *viz.* the weight that sustains it. To this class of forces may also be referred centripetal and centrifugal forces, though they reside in a body in motion, because these forces are homogeneous to weights, pressures, or tensions of any kind. The force of a body in motion, is a power residing in that body, so long as it continues its motion; by means of which, it is able to remove obstacles lying in its way, to lessen, destroy, or overcome the force of any other moving body, which meets it in an opposite direction; or to surmount any the largest dead pressure or resistance, as tension, gravity, friction, &c. for some time; but which will be lessened or destroyed by such resistance as lessens or destroys the motion of the body. This is called *vis motura*, moving force, or motive force, and by some late writers *vis viva*, to distinguish it from the *vis mortua*, spoken of before.

FORCE, is distinguished into *motive* and *accelerative*, or *retardive*, *constant*, *variable*, &c.

Motive FORCE, otherwise called *momentum*, or force of percussion, is the absolute force of a body in motion, &c.; and is expressed by the product of the weight or mass of matter in the body, multiplied by the velocity with which it moves. *Motive* FORCE also denotes the force by which a system of bodies is put in motion, as it is the difference between the power or weight which produces the motion, and the resistance or weight to which it is opposed.

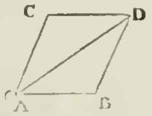
Accelerative FORCE, or retardive force, is that which respects the velocity or rate of motion only, accelerating or retarding it; and it is denoted by the quotient of the motive force, divided by the mass or weight of the body. So,

If m denote the motive force,
and b the body, or its weight,
and f the accelerating or retarding force,

then is f as $\frac{m}{b}$

Constant FORCE, is such as remains and acts continually the same for some determinate time. Such, for example, is the force of gravity, which acts constantly the same upon a body while it continues at the same distance from the centre of the earth, or from the centre of force, wherever that may be. Constant or uniform forces produce uniformly accelerated motions, the laws of which will be found under the article ACCELERATION. *Variable* FORCE, is that which is continually changing its effect and intensity, such as the force of gravity at different distances from the earth's centre. See the formulæ relating to variable forces under the article ACCELERATION. Forces are farther distinguished into *central*, *centrifugal*, &c. which see under the several articles.

Composition of FORCES, may be thus defined:—If two or more forces differently directed, act upon the *same* body, at the *same time*, as the body in question cannot obey them all, it will move in a direction somewhere *between* them. This is called the *composition* and resolution of forces or of motion, and may be illustrated in the following manner:—*Illus.* Suppose a body A to be acted upon by a force in the direction A B, while at the same time it is impelled by another force in the direction A C, it will then move in the direction A D; and if the lines A B, A C, be made of lengths proportionate to the forces, and the lines C D, D B, be drawn parallel to them, so as to complete the parallelogram A B D C, then the line which the body A will describe, will be the diagonal A D; and the length of this line will represent the force with which the body will move. But if the body be impelled by equal forces acting at right angles to each other, it will move in the diagonal of a square. Instances in nature, of motion produced by several powers acting at the same time, are innumerable. A ship impelled by the wind and tide is one well known; a paper kite, acted upon in one direction by the wind and in another by the string, is another instance.



Animal FORCE, *as applied to Machinery*. All machines are impelled, either by the exertion of animal force, or by the application of the powers of nature. The latter comprise the potent elements of water, air, and fire. The former is more common, yet so variable as hardly to admit of calculation; it depends not only on the vigour of the individual, but on the different strength of the particular muscles employed. Every animal exertion is attended by fatigue; it soon relaxes, and would speedily produce exhaustion. The most profitable mode of applying the labour of animals, is to vary their muscular action, and revive its tone by short and frequent intervals of repose.

The ordinary method of computing the effects of human labour is, from the weight which it is capable of elevating to a certain height, in a given time, the product of these three numbers expressing the absolute quantity of performance. This was reckoned by Daniel Bernoulli and Desaguliers at two millions of pounds avoirdupois, which a man could raise one foot in a day. But our civil engineers have gone much farther, and are accustomed, in their calculations, to assume, that a labourer will lift ten pounds to the height of ten feet every second, and is able to continue such exertion for ten hours each day, thus accumulating the performance of 3,600,000. But this estimate seems to be drawn from the produce of momentary exertions, under the most favourable circumstances; and it therefore greatly exceeds the actual results, as commonly depressed by fatigue, and curtailed by the unavoidable waste of force.

Coulomb has furnished the most accurate and varied observations on the measure of human labour. A man will climb a stair, from 70 to 100 feet high, at the rate of 45 feet in a minute. Reckoning his weight at 155 lbs., the animal exertion for one minute is 6,975, and would amount to 4,185,000 if continued for ten hours. But such exercise is too violent to be often repeated in the course of a day. A person may clamber up a rock 500 feet high by a ladder-stair in twenty minutes, and consequently at the rate of 25 feet each minute; his efforts are thus already impaired, and the performance reaches only 3,875 in a minute.

But, under the incumbrance of a load, the quantity of action is still more remarkably diminished. A porter weighing 140 lb. was found willing to climb a stair 40 feet high 266 times in a day; but he could carry up only 66 loads of fire-wood, each of them 163 lb. weight. In the former case, his daily performance was very nearly 1,500,000; while, in the latter, it amounted only to 808,000. The quantity of permanent effect was hence only about 700,000, or scarcely half the labour exerted in mere climbing. In the driving of piles, a load of 42 lb., called the *ram*, is drawn up 3½ feet high 20 times in a minute; but the work has been considered so fatiguing as to endure only three hours a day. This gives about 530,000, for the daily performance. Nearly the same result is obtained, by computing the quantity of water, which by means of a double bucket, a man drew up from a well. He lifted 36 lb. 120 times in a day from a depth of 120 feet, the total effect being 518,400. A skilful labourer working in a field with a large hoe, creates an effect equal to 728,000. When the agency of a winch is employed in turning a machine, the performance is still greater, amounting to 845,000.

In all these instances, a certain weight is heaved up, but a much smaller effort is sufficient to transport a load horizontally. A man could, in the space of a day, scarcely reach an altitude of two miles by climbing a stair; though he will easily walk over thirty miles on a smooth and level road. But he would in the same time carry only 130 lb. to the fourth part of that distance, or 7½ miles. Assuming his own weight to be 140 lb., the quantity of horizontal action would amount to 42,768,000, or twenty-eight times the vertical performance; but the share of it in conveying the load is 20,961,780, or about thirty times what was spent in its elevation. The greatest advantage is obtained by reducing the burden to 102 lb., the length of journey being augmented in a higher ratio.

These results are apparently below the average of English labour, which is not only most vigorous, but, in many cases, quite overstrained. Moderate exertion of strength, joined to regularity and perseverance, would be more conducive to robust health, and the comfortable duration of human life.

A porter in London is accustomed to carry a burden of 200 lb. at the rate of three miles an hour. In the same metropolis, a couple of Irish chairmen continue at the pace of four miles an hour, under a load of 300 lb. These exertions are greatly inferior, however, to the labour performed by porters in Turkey, the Levant, and generally on the shores of the Mediterranean. At Constantinople, an Albanian porter will carry 800 or 900 lb. on his back, stooping forward, and assisting his steps by a sort of staff. At Marseilles, four porters commonly carry the immense load of nearly two tons, by means of soft hods passing over their heads, and resting on their shoulders, with the ends of poles, from which the goods are suspended.

According to some experiments of the late Mr. Buchanan, the exertions of a man in working a pump, in turning a winch, in ringing a bell, and in rowing a boat, are as the numbers 100, 167, 227, and 248. But those efforts appear to have been continued for no great length of time. The Greek seamen, in the Dardanelles, are esteemed more skilful and vigorous in the act of rowing, than those of any other nation. Even the Chinese, applying both their hands and their feet, are said to surpass all people in giving impulsion to boats by sculling.

The several races of men differ materially in strength, but still greater diversity results from the constitution and habits of the individual. The European is, on the whole, decidedly more powerful than the inhabitants of the other quarters of the globe; and man, reared in civilized society, is a finer, robuster, and more vigorous animal than the savage. In the temperate climates, likewise, men are capable of much harder labour, than under the influence of a burning sun. Coulomb remarks, that the French soldiers employed on the fortifications of the Isle of Martinique became soon exhausted, and were unable to perform half the work executed by them at home.

The most violent and toilsome exertion of human labour is performed in Peru, by the *cerriers* or *cargueros*, who traverse the loftiest mountains, and clamber along the sides of the most tremendous precipices, with travellers seated on chairs strapped to their backs. In this manner, they convey loads of 12, 14, or even 18 stones; and possess such strength and action, as to be able to pursue their painful task eight or nine hours, for several successive days. These men are a vagabond race, consisting mostly of mulattoes, with a mixture of whites, who prefer a life of hardship and vicissitude, to that of constant though moderate labour.

When a man stands, he pulls with the greatest effect; but his power of traction is much enfeebled by the labour of travelling. If v denote number of miles which a person walks in an hour, the force which he exerts in dragging forward a load will be expressed nearly by $\frac{1}{5}(12-2v)^2$. Thus, when at rest, he pulls with a force of about 29 pounds averdupois; but if he walks at the rate of two miles an hour, his power of traction is reduced to 14 lb.; and if he quicken his pace to four miles an hour, he can draw only 3 lb. There is consequently a certain velocity which procures the greatest effect, or when the product of the traction by the velocity becomes a *maximum*. This takes place when he proceeds at the rate of two miles an hour. The utmost exertion which a man walking might continue to make in drawing up a weight by means of a pulley, would amount, therefore, in a minute, only to 2,430; but if he applied his entire strength, without moving from the spot, he could produce an effect of 3,675.

The labour of a horse in a day, is commonly reckoned equal to that of five men; but then he works only eight hours, while a man easily continues his exertions for ten hours. Horses likewise display much greater force in carrying than in pulling; and yet an active walker will beat them on a long journey. Their power of traction seldom exceeds 144 pounds, but they are capable of carrying more than six times as much weight. The pack-horses in the West Riding of Yorkshire are accustomed to transport loads of 420 lb. over a hilly country. But, in many parts of England, the mill-horses will carry the enormous burden of 910 lb. to a short distance. With regard, however, to the ordinary power of draught, the formula $(12-v)^2$ where v denotes the velocity in miles an hour, will perhaps be found sufficiently near the truth. Thus, a horse beginning his pull with the force of 144 lb., would draw 100 lb. at a walk of two miles an hour, but only 64 lb. when advancing at double that rate, and not more than 36 lb. if he quickened his pace to six miles an hour. His greatest performance would hence be made with the velocity of four miles an hour. The accumulated effort in a minute will then amount to 22,528. The measure generally adopted for computing the power of steam engines is much higher, the labour of a horse being reckoned sufficient to raise, every minute, to the elevation of one foot, the weight of 32,000 lb. But this estimate is not only greatly exaggerated, but should be viewed as merely an arbitrary and conventional standard.

Wheel carriages enable horses, on level roads, to draw, at an average, loads about fifteen times greater than the power exerted. The carriers between Glasgow and Edinburgh transport, in a single-horse cart, weighing about 7 cwt., the load of a ton, and travel at the rate of 22 miles a day. At Paris, one horse, in a small cart, conveys along the streets, half a cord of wood, weighing two tons; but three horses yoked in a line are able to drag 105 cwt. five and a fourth, or that of a heavy cart loaded with building stones. The Normandy carriers travel from 14 to 22 miles a day, with two-wheeled carts, weighing each 11 cwt., and loaded with 79 cwt. or nearly 4 tons, of goods, drawn by a team of four horses.

The French draught horses, thus harnessed to light carriages, are more efficient perhaps than the finer breeds of this country. They perform very nearly as much work as those in the single-horse carts used at Glasgow, and far greater than those heavy animals which drag the lumpish and towering English waggons. The London dray-horses, in the mere act of ascending from the wharfs, display a powerful effort, but they afterwards make little exertion, their force being mostly expended in transporting their own ponderous mass along.

Oxen, on account of their steady draught, are in many countries preferred for the yoke. They were formerly employed universally in the various labours of husbandry. The tenderness of their hoofs, unless shod, however, makes them unfit for pulling on paved roads, and they can work only with advantage in soft grounds. But they want all the pliancy and animation, which are the favourite qualities of the horse.

The patient drudgery of the ass, renders him a serviceable companion of the poor. Though much inferior in strength to the horse, he is maintained at far less cost. In this country, an ass will carry about two hundred weight of coals or limestone, twenty miles a day. But, in the warmer climates, he becomes a larger and finer animal, and trots or ambles briskly under a load of 150 pounds. The mule is still more powerful and hardier, being fitted equally for burden and draught.

In the hotter parts of Asia and Africa, the ponderous strength of the elephant has been long turned to the purposes of war. He is reckoned more powerful than six horses, but his consumption of food is proportionally great. The elephant carries a load of three or four thousand pounds,—his ordinary pace is equal to that of a slow trot,—he travels easily over forty or fifty miles in a day, and has been known to perform, in that time, a journey of a hundred and ten miles. His sagacity and intelligence direct him to apply his strength according to the exigency of the occasion.

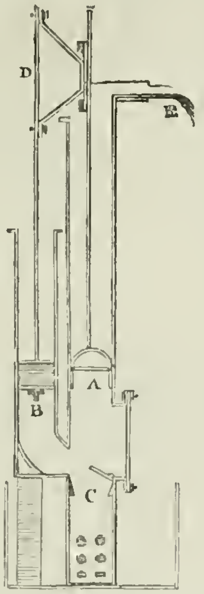
The camel is a most useful beast of burden in the arid plains of Arabia. The stronger ones carry a load of ten or twelve hundred weight, and the weaker ones transport six or seven hundred; they walk at the rate of two miles and a half in an hour, and march about thirty miles every day. The camel travels often eight or nine days, without any fresh supply of water; when a caravan encamps in the evening, he is perhaps turned loose, for the space of an hour, to browze on the coarsest herbage, which serves him to ruminate during the rest of the night. In this manner, without making any other halt, he will perform a dreary and monotonous journey of two thousand miles.

Within the Arctic Circle again, the rein deer is a domesticated animal, not less valuable. He not only feeds and clothes the poor Laplander, but transports his master with great swiftness, in a covered sledge, over the snowy and frozen tracts. The rein deer subsist on the scanty vegetation of moss or lichens, and, though very docile, they are not powerful. Two of them are required to draw a light sledge: so harnessed, they will run fifty or sixty miles on a stretch, and sometimes perform a journey of a hundred and twelve miles in the course of a day. But such exertions soon wear them out.

A sort of dwarf camel was the only animal of burden possessed by the ancient Peruvians. The Lama is, indeed, peculiarly fitted for the lofty regions of the Andes. The strongest of them carry only from 150 to 200 pounds, but perform about fifteen miles a day over the roughest mountains. They generally continue this labour during five days, and are then allowed to halt two or three days before they renew their task. The Paco is another similar animal, employed likewise in transporting goods in that singular country; it is very stubborn, however, and carries only from fifty to seventy pounds.

Even the exertions of goats have, in some parts of Europe, been turned to useful labour. They are made to tread in a wheel which draws water, or raises ore from the mine. Though a very light animal, the goat is nimble, and climbs at a high angle. Supposing this soaring creature, though only the fourth part of the weight of a man, to march as fast along an ascent of 40 degrees, as he does over one of 18 degrees,—the sine of the former being double that of the latter,—it must yet perform half as much work.—*Leslie's Elements of Natural Philosophy.*

FORCEPS, in Surgery, &c. a pair of scissars for cutting off, or dividing, the fleshy membranous parts of the body, as occasion requires.



FORCER, TEMPORARY, for a pump, is a contrivance to produce a constant stream. A very simple forcer of this kind has been devised by Mr. R. Trevithick: it consists in fixing a barrel with solid piston along the side of the common pump, in such a manner that the lower space of the additional barrel may communicate with the space between the two valves of the pump; and lastly, by connecting the rods at D, so that they may work together. This is shewn in the annexed figure, and the effect is, that when the pistons are raised, the spaces of the cylinders beneath, A and B, become filled by the pressure of the atmosphere, at the same time that the upper column flows out at E, the discharging spout.

But again, when the pistons descend, the valve C shuts, and consequently, the water driven by the piston in B must ascend through A, and continue to produce an equal discharge through E in the down stroke.

FORCING, among Gardeners, signifies the making trees produce ripe fruit before their usual time. This is done by planting them in a hot-bed against a south wall, and likewise defending them from the injuries of the weather by a glass frame. They should always be grown trees, as young ones are apt to be destroyed by this management. The glasses must be taken off at proper seasons, to admit the benefit of fresh air, and especially of gentle showers.

FORE, the distinguishing character of all that part of a ship's frame and machinery which lies near them.

FORE *and Aft*, throughout the ship's whole length, or from end to end; it also implies, in a line with the keel. *Fore Bow Line*, the bow-line of the fore-sail. *See* BOW LINE.

FORE *Braces*, ropes applied to the fore yard-arms, to change the position of the fore-sail occasionally.

FORE *Castle*, a short deck placed in the fore part of a ship above the upper deck; it is usually terminated both before and behind in vessels of war by a breast-work, the foremost part forming the top of the beak head, and the hind part reaching to the after part of the fore chains. *Fore Castle Men*, sailors stationed on the fore castle, who are generally prime seamen.

FORE *Cat-Harpings*, a complication of ropes used to brace in the upper part of the fore shrouds.

FORE *Closed*, in Law, signifies the being shut out, and excluded or barred. the equity of redemption on mortgages, &c.

FORE *Foot*, a piece of timber which terminates the keel at the fore end; it is connected by a scarf to the extremity of the keel, and the other end of it which is incurvated upwards into a sort of knee, is attached to the lower end of the stem; it is also called a gripe. As the lower arm of the fore foot lies on the same level with the keel, so the upper one coincides with the middle line of the stem; its breadth and thickness therefore correspond with the dimensions of those pieces, and the heel of the cutwater is scarfed to its upper end.

FORE *Land*, a cape or promontory projecting into the sea, as the North and South Forelands.

FORE *Tackle*, tackle on the fore mast, and also tackle used for stowing the anchor. *Foretop Men*, men stationed in the foretop, in readiness to set, or take in the smaller sails, and to keep the upper rigging in order.

FORE *Runner of the Line*, a small piece of red buntin, laid into that line at a certain distance from the log, the space between them being called the stray line, which is usually from twelve to fifteen fathoms, and is an allowance for the log to be entirely out of the ship's dead water, before they begin to estimate the ship's velocity, consequently the knots begin from that point. *See* the article LOG.

FORE *Staff*, is an instrument used at sea for taking the altitudes of heavenly bodies. The fore staff, called also cross staff, takes its denomination hence, that the observer in using it turns his face towards the object, in contradistinction to the back staff, where he turns his back to the object.

FOREIGN SEAMEN, serving two years on board British ships, whether of war, trade, or privateers, during the time of war, shall be deemed natural-born subjects.

FOREJUDGER, in Law, a judgment whereby a man is deprived, or put out, of the thing in question.

FOREST, in Law, a certain territory of woody ground and fruitful pastures, privileged for wild beasts and fowls of forest, chase, and warren, to rest and abide under the protectionof the king, for his princely delight. Every forest is supposed to be bounded by unremovable marks and meres, either known by matter of record or prescription. Besides the New Forest in Hampshire, there are 68 other forests in England, 13 chases, and more than 700 parks. New Forest lies on the sea side, Hampshire, Kirwood forest is on the banks of the Trent, Dean forest on the Severn, and Windsor forest on the Thames. A forest strictly taken cannot be in the hands of any but the king, who alone has power to grant a commission to the justice in eyre of the forest; yet if he grants a forest to a subject, that subject and his heirs shall have a *justicias* in the forest, in which case the subject has a forest in law. Beasts of the forest are the hart, hind, buck, doe, bear, wolf, fox, hare.

FOREST *Courts* take cognizancee of all trespasses committed in the said forests, whether these be injuries done to the venison, the vert, or greensward, or to the covert in which such deer are lodged. And the *forest laws* are laws peculiarly applicable to the forests, being different from the common law of England.

FORESTALLING, is the buying or bargaining for any corn, cattle, or other merchandise, by the way, before it comes to any market or fair to be sold; or as it comes from beyond the seas, or otherwise, towards any port or creek of this realm, to sell the same again at a higher price. At the common law, all endeavours to enhance the price of merchandise, and all practices which have a tendency thereto, whether by spreading false rumours, or by purchasing things in a market before the accustomed hour, or by buying and selling again the same thing in the same market, or by such devices, are criminal, and punishable by fine and imprisonment.

FORESTER, a sworn officer of the forest, appointed by the king's letters patent to walk the forest at all hours, watch over the vert and venison; also to make attachments and true presentments of all trespasses committed within the forest.

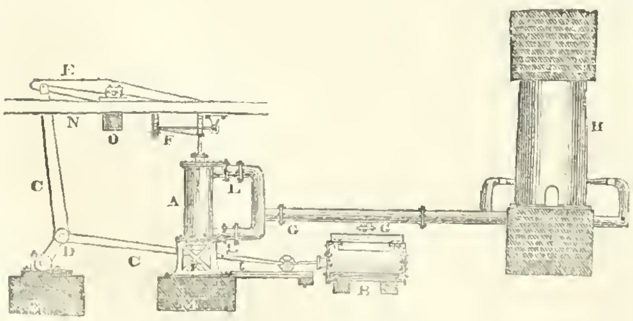
FORFEITURE, in Law, a transgression, or offence, or more properly speaking, the effect of such transgression, as the loss of privilege, right, estate, honour, office, or effects, either in *civil* or *criminal* cases. In *civil* cases, as when a tenant in tail makes leases not warranted by the statute, a forfeiture is committed, and he who has the immediate reversion may enter upon possession. In *criminal* cases, it is two-fold; of real and personal estates, as by attainder in high treason; or in petty treason and felony, of all chattel interests absolutely, and the profits of all freehold estates during life and after death, of all lands and tenements in fee simple (but not those in tail), to the crown for a year and a day, &c. Lands are forfeited upon attainder, and not before; goods and chattels are forfeited by conviction.

FORFICULA, *Earwig*, an insect of the coleoptera order. The wings of this insect are remarkably elegant, and are convoluted beneath their small sheaths in a curious manner; they are very large in proportion to the animal, transparent, and slightly iridescent. The earwig flies only by night, and it is with difficulty made to expand its wings by day. The popular dread in which this insect is held, on a supposition of its sometimes entering the ear, and piercing the timpanum, is considered by some as problematical, though there are undoubtedly instances of earwigs having accidentally taken shelter in the ears of persons asleep, and occasioning great pain. The best means of expelling them is, to drop a small quantity of brandy or other spirit into the ear.

FORGE, a little furnace, as that used by smiths, &c. or, simply, a pair of bellows, the muzzle of which is directed upon a smooth area, on which coals are placed. *See* BELLOWS.—*Forge* is also used when speaking of a large furnace, wherein iron ore taken out of the mine, is melted down; or it is more properly applied to another kind of furnace, wherein the iron ore melted down and separated in a former furnace, and then cast into sows and pigs, is heated and fused over again, and beaten afterwards with large hammers, and thus rendered more soft, pure, ductile, and fit for use.

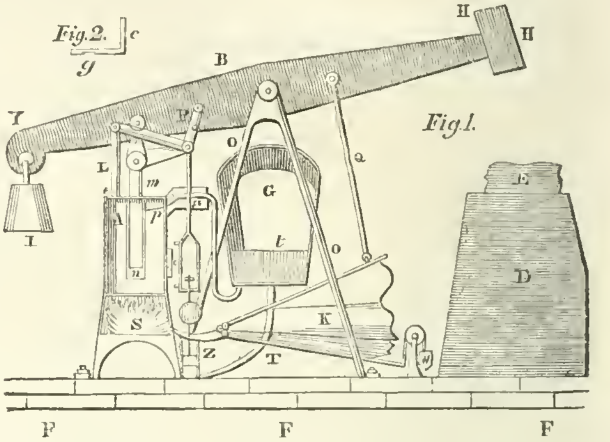
FORGE *Blowing Engine*, by Mr. Paterson, Lanark. The improvement in this blowing engine is, that by the use of two cylinders blowing alternately, the blast is equalized without either a water-pressure or an air-vessel; and thus, without the aid of these, and with less weight upon the moving power, whether steam-engine or water-wheel, a constant and steady blast is obtained.

Description.—This machine has been used for some time back. It is driven by a water-wheel of five horse power, and has been found preferable to a blast from one cylinder. Mr. Paterson can smelt at least one-third more iron with the same quantity of coke, and make larger pigs; and besides, the iron is much more fluid or better fused, than was the case when he used the blowing engine with one cylinder. He farther considers it a great advantage for the machinery, as it entirely does away jolting, the crank being alike strained at all points. A, (see the engraving,) the upright cylinder; B, the horizontal cylinder; C, C, the two connecting rods; D, the crank; E, the walking beam; F, the parallel motion; G, the pipes for conveying the blast to the cupola; H, the cupola or furnace; I, the small wheel, running upon a cast iron bar, with a groove in its top, in order to keep the piston rod parallel; K, is two cast iron plates standing on edge, to allow the connecting rod to move between them, and to support the upright cylinder; L, L, the chests where the valves are placed to admit the air into the upright cylinder, but they cannot be shewn in the plate. The valves in the horizontal cylinder are fixed to the ends of the cylinder, and open inwards to admit the air into it. M, M, the pedestals for the cylinder and crank to be fixed upon; N, the spring beams for carrying the walking beam; O, a beam to go across the house to support the spring beams and the walking beams.—*Glasgow Mech. Mag.*



FORGE *Furnace.* The forge furnace consists of a hearth, upon which a fire may be made, and urged by the action of a large pair of double bellows, the nozzle of which is inserted through a wall or parapet constructed for that purpose. Black lead pots, or small furnaces of every desired form, may be placed, as occasions require, upon the hearth; and the tube of the bellows being inserted into a hole in the bottom of the furnace, it becomes easy to urge the heat to almost any degree required.

FORGE *Hammer*, moved by steam. We shall here present our readers with a recent application of steam to work a forge hammer, which from the engraving and description, must be easily understood by all persons connected with iron factories.



Description.—A, the cylinder, the bottom, *n*, of which is kept very hot by the fire in the stove, S. B, the beam, vibrating on a centre, C. D, the anvil. E, the iron to be forged. F, F, F, the foundation or floor for the machine to rest on. G, a cistern, filled with water as high as *t*, and the remaining part with air. H, the hammer. I, a weight, heavy enough to lift the hammer, and to overcome the friction of the machine. K, a pair of smith's bellows inverted, which receives motion from the beam, B, by means of the connecting rod, Q. L, an upright shaft, fastened to the top of the cylinder, A, to which the radius rod of the parallel motion, P, is fixed. R, a rod to let water into the cylinder, move the forcing pump, Z, and let steam out of the cylinder. This rod has a hole in it about one-eighth of an inch long; and when the hammer is at its greatest height, as is shewn in the figure, this rod is at the bottom; the hole, *a*, comes opposite to the pipe, *p*, and allows the water to be forced out of the cistern, G, into the cylinder, A, (which is made air-tight at top, *m*, and rather broader in the inside, to allow the water to pass to the bottom, *n*,) which is immediately converted into steam, and thus gives a very great force to the hammer. This rod at the same time shuts the communication with the atmosphere, by means of the pins *x x*, and crank *c*, more fully exhibited in fig. 2. When the end, Y, of the beam is at the top, the bottom pin, *a*, lifts up the crank, *e*, and allows the steam to pass through the groove *g*, (which is made in the steel cock, *c g*, exactly to the centre,) into the atmosphere, and allows the piston to descend. The piston of the forcing pump, Z, is also lifted by this rod by the catch, *f*; but as the beam descends, it does not force down the piston, but lets the weight, *w*, force the water up the pipe, T, according as it is consumed. *w*, a cock for stopping the engine.—*London Mech. Mag.*

FORGERY, in Common Law, the fraudulent making or altering of writing to the prejudice of another man's right; for which the offender may suffer imprisonment, banishment, death. Forgeries in court rolls, wills, deeds, bonds, acquittances of debts, are all felonies; in bank bills, bills of credit, promissary notes, stamps, &c. felonies without benefit of clergy; aiding and abetting in any forgery of a deed, bond, bill of exchange, indorsement, assignment, &c. is felony without benefit of clergy. *See* Printing.

FORLORN Hope, in the Military art, signifies men detached from several regiments, or otherwise appointed, to make the first attack in day of battle, or at a siege to storm the counterscarp, mount the breach, or the like. They are so called from the great danger they are unavoidably exposed to.

FORM, Printer's, an assemblage of letters, words, and lines, disposed into pages by the compositor, and from which the printed sheets are taken.

FORMA Pauperis, in Law, is when any person having cause of suit, and cannot support the charges, upon affidavit, that he is not worth five pounds, the court admits him to sue without fees or paying costs.

FORMATIONS, the rocks and other solid arrangements of matter, of which the globe is composed, are considered by geologists as having been formed at different times; and hence they speak of older and later *formations*, limestone formations, sandstone formations, and such like.

FORMIATES, compounds of the formic acid with earths, alkalies, and metallic oxides.

FORMIC Acid, is obtained from ants, either by simple distillation, or by infusing them in hot water, and afterwards distilling. It may afterwards be purified by repeated rectification, or it may be done in the time of frost. This acid has been employed by quacks to relieve the pain of the toothache. It has a very sour taste, and remains liquid at a low temperature. Specific gravity at 68° is 1·1168.

FORMICA, the *Ant*, a well-known insect of the class hymenoptera. There are eighteen species, which live in a social state, and are divided into males, females, and neutrals. These last conduct the business of the nest, which is usually placed at a little distance from the surface, in some slight elevation prepared by the insects themselves, or previously formed by moles, &c. Ants feed on animal and vegetable substances, devouring caterpillars, &c. as well as fruits.

FORMULA, or Form, in Analysis, is any general theorem or literal expression, and is said to be algebraical, logarithmic, trigonometrical, &c. according as it relates to either of these subjects.

FORNICATION, the act of incontinency in single persons; for if either party be married, it is adultery. The spiritual court hath the proper cognizance of this offence; but formerly the courts-leet had the power to inquire of and punish fornication and adultery; in which courts the king had a fine assessed on the offenders, as appears by the book of doomsday.

FORT, a small fortified place environed with a moat, rampart, and parapet. Forts are of different figures and magnitudes. Some are fortified with bastions, and others with demi-bastions. See the following articles.

FORTIFICATION, a species of Military Architecture, consists of the planning and erecting of such works of defence, agreeably to geometrical principles, as may protect a town, or any position, from the capture of an enemy. But the reader must not expect here to find a treatise on each branch of the art. Confining ourselves to facts and terms, our observations will savour more of definitions than rules for practice. Fortification is usually divided into ancient and modern; offensive and defensive; regular and irregular.

Ancient Fortification consisted principally of defences constructed with trunks and branches of trees, mixed with earth, for security against the attacks of an enemy. Afterwards, when battering rams, catapults, and other instruments of attack were invented, fortifications were constructed of thick walls of brick or stone, with towers, placed at suitable distances.

The object of *Modern Fortification* is to furnish defence against assailants with fire-arms; the walls are turned into ramparts, the towers into bastions, defended by numerous outworks, so constructed that they cannot be beaten down but by the fire of cannon. The works are contrived so, that one part flanks or defends another, and render the approach of the besiegers to any part very dangerous.

Regular Fortifications, are erected in the shape of regular polygons, the sides being at least a musket-shot from each other, and fortified according to the rules of art. *See* Bastion. —*Irregular Fortifications*, on the contrary, are those whose sides and angles are not uniform, owing to some irregularity of the ground. These usually occur in

Field Fortification, or the constructing of temporary works for an army intrenched, or fortified in the field. In this position it covers a country, supplies the want of numbers, stops a superior enemy, or obliges him to engage at a disadvantage. The materials used for field fortifications, are such as can be readily obtained, *viz.* sand bags, earth, and fascines, or fagots of small wood, ten feet long and one foot thick, fastened to the parapet by pickets driven obliquely into the bank. Turf is sometimes used when wood cannot be procured, being four inches thick and eighteen inches square. Bridges of boats are employed for facilitating the transport of troops across deep rivers, and arms or straits of the sea. *See* Bastion.

A new method of Defending Ships and Fortifications against Cannon-balls, and of causing them to fly back again on the Enemy. By Lewis Gompertz, Esq.

Having made some experiments on a plan which I had designed, for rendering ships and fortifications shot-proof, and of causing several of the balls which might be fired against them, to return upon the enemy; and having found my experiments (which were on a small scale) to answer my expectations, I have here to explain the nature of the plan, with the hopes that it may be farther considered by those, whose scientific and practical information qualify them for judging how far it might succeed on a large scale.

But before I enter into this description, I think it proper to observe, that the chief utility it may promise, is in its application to merchant vessels, ships of passage, &c. and for fortifications; but for ships of war (as it could be adopted by both parties) its effect would become *neutralized*, though it seems, that even in this case it would save the men from injury, and would always be in favour of the weak and defensive side, its nature being that of defending itself, and returning the blows, but without any power of attacking, unless furnished with guns also.

Figs. 4 and 5, shew two views of a ship made on the plan; fig. 3, is a section of a side drawn larger; the form of it being apparent by the drawing. In the three figures, 3. 4, and 5, the same letters refer to the same parts. N W A L is a concave curve to return the balls which strike it, and P C O is a triangular piece (extending beyond N M and L K) which goes all round the ship, to protect the most perpendicular part of the curve W A from being struck directly, (otherwise it would be easily perforated,) and which triangular piece, on being struck somewhat horizontally, evades the balls, and guides them properly to the return part N W A L, so that they follow the shape of it, and return. The part N M above the curve where the port-holes are, and the part L K Q below it, are made oblique, to evade those balls which strike them, the part N M sending them upwards, and the part L K Q directing them into the water, though it must be confessed, that some of the former would thereby occasionally be thrown into the rigging. There are a number of supports shewn near P, fig. 4, and also faintly expressed in fig. 5, which fasten the triangular piece to the ship, and the more acute the outward angle is, the less force will it generally be struck with.

Fig. 1, is also a section of a side of a different construction, but inferior, and less applicable; though, being more simple, and on nearly the same principles, I will describe the nature of that first, or rather both together, the same reasoning applying to each. B C is the side forming an acute angle with the water, and extending some way under the water, but not far, as balls do not generally penetrate that part of a ship which is far below the surface of the water. S T is a board placed as shewn, shaded, so that there shall exist a vacancy between itself and the side of the ship; this vacancy grows progressively less upwards, till there is only room left for a ball to pass; and the board is fastened by different supports in places to the ship, but these are not put in this figure, as they would hide the operation. The part W is so curved as to return the balls after they have struck the inclined part, but as *in this construction* the return part might be struck by balls coming directly against it, without their having struck the inclined part, it might be required to make the most perpendicular place of it near P, strong enough to *resist* the balls, this portion of the curve being very small. The effects then will vary in different cases, and will depend on the *hardness*, and on the *elasticity*, of the material of the side of the ship, and of the ball; also on the force with which the balls are fired. The following results, it seems, would then be produced :—

Case 1. If the ball and the side were perfectly elastic, and of sufficient hardness not to be broken, or if *only* the side were perfectly elastic, then, according to the established law, the ball would be reflected backwards and forwards in fig. 1, between the side C B and board S T, and in fig. 3, between I C and I H, at equiangles, and would *not* follow the shape of the curve; and if the force of the ball should not be too much destroyed by the operation, it would at last be reflected off, though most likely not in a proper direction to reach the enemy.

2dly. If neither the side nor the ball should possess any elasticity, and the side were perfectly hard, whether the ball should be hard, or whether it should be soft, (so as to indent,) it would be turned out of the direction, and would in fig. 1, if struck at H, proceed up the inclined side B C, then following the shape of the curve W, (the motion of the centre being shewn dotted at I P Q,) and it would then return to x; and in fig. 3, if it should strike at H, it would proceed in the direction of the whole shape N W A L, (the motion of the centres being shewn dotted at H I J R,) and it would return as the arrows point; but if, in fig. 1, it should strike at V, or in fig. 3, at G, the respective balls would, after sliding or rolling up the boards T S fig. 1, and I C, fig. 3, strike each of the curves in such a direction as to follow their shapes and return, without any reflection taking place; and in fig. 3, those balls which entered at G would return at x, and *vice versa*.

Fig. 4.

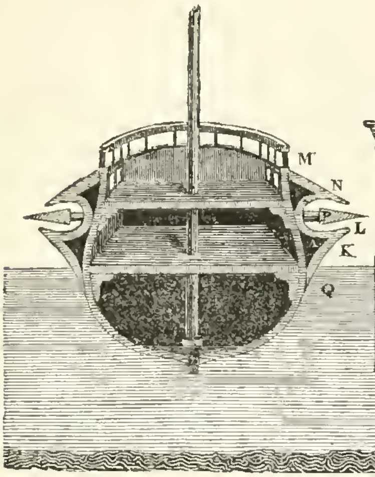


Fig. 5.

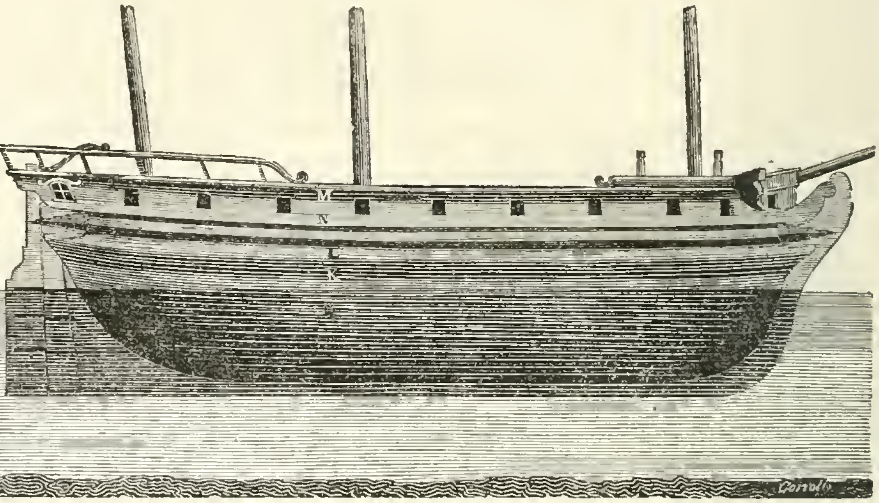


Fig. 3.

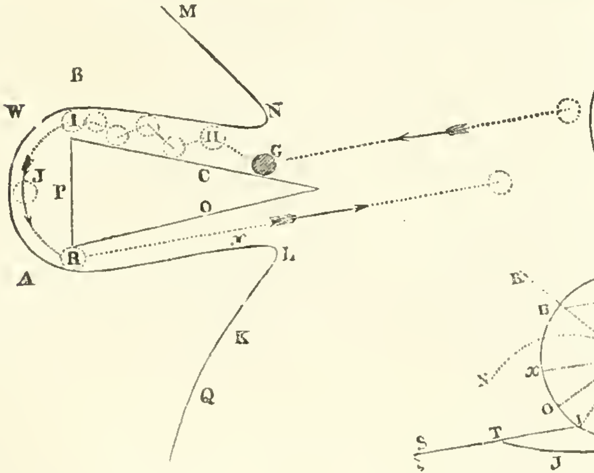
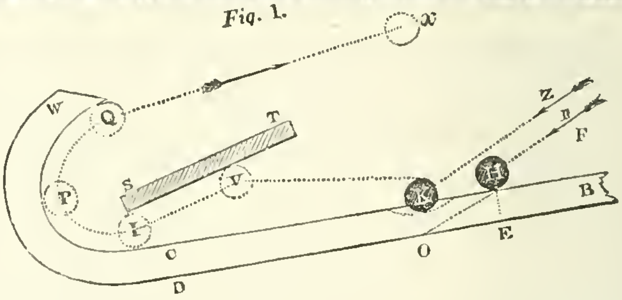


Fig. 1.



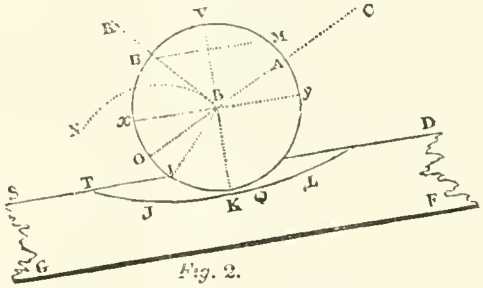


Fig. 2.

Case 2. If the force of the ball K, fig. 1, should only be so far evaded by the inclination of the side, as to penetrate to about half the depth of its own size or less, (shewn large at $x\,y$, fig. 2,) and if there were no elasticity in the substances, there would, it seems, then arise a great force to repel the ball beyond what is immediately caused by the inclination of the side, on account of the rotary motion the ball would have acquired by its action against the inside of the indentation; then suppose B A H Q, fig. 2, be a section of a ball going nearly in a parallel direction C B, and suppose I K L Q be the indentation, in which place we will fancy the substance of the side to be so hard as not to give way any more; the effect, it seems, would then be, that the centre of the ball B would *begin* to describe part of a circle B N, about the centre I, (the point where the indentation and the remainder of the side meet, and of the size of the ball itself.) Then, if the indentation should be deep and the velocity great, the ball would be forced completely out of it, and fly far above the top of the ship, because the part of the circle B N which the centre B of the ball would *begin* to describe, would be nearly perpendicular to the side S D, and as there would be nothing to change the direction of the ball after it had once acquired this new motion, it would fly off in the direction of the most perpendicular part of the circle B N, and continue in this direction, though not of the *continued* circle B N, but in a straight line B R; if, however, the indentation should be small, the line B R would be more nearly parallel to the side S D, in which case, the motion of the ball would not be caused to differ so much from the direction of the side, but that it might strike the flat board T S, fig. 1, in a direction K V, which would prevent it from flying away, and direct it to the side again, so that it followed the return part and flew back again, after having been reflected backwards and forwards (not by means of any elasticity,) but by the reaction of the inside surface of the indentation against the ball, as before described; and as there would be a loss of force at every blow, each indentation would be less than the preceding one, and each angle of reflection would be more obtuse, as is shewn in fig. 3, till the ball arrived at the return part W A, so as to follow the shape of it, ceasing sensibly to rebound when the indentation ceased sensibly to take place; but as the indentation and point, I, would not be so hard as assumed, the effect would not be exactly as described; though, as there would be a continual tendency for it to be so, according to the hardness of the side, it would be produced to a certain degree, and the ball would accordingly continually widen the indentation, and come out at some other point T, instead of I, fig. 2; and as the new direction would, by the yielding of the substance, be less perpendicular than when the material was extremely hard, the ball would be the more inclined to follow the curvature of the side, and to return, and the less inclined to fly over the top of the ship, as the angles of reflection would thereby become still more obtuse every time that the indentations it would produce in its course would widen, as just alluded to.

It seems that the tendency of being reflected by the reaction of the indentation would exist, in some degree, till the ball was completely buried, allowing the material of the side of the ship to be as deep as the ball; because, suppose the ball be partially buried to H M, fig. 2, (above the diameter,) and allowing even that it should still be as much inclined to go in its original direction C B as it was at first, (though it is evident, that it must have acquired some tendency to alter its direction, by the blow, &c.;) then, to see this clearly, to the diameter $x y$, which is parallel to the side of the ship, draw another diameter V K, perpendicular to it. It will then be obvious, that as the ball continued to penetrate, it would be opposed at its whole buried surface H K, and it is also plain that if the resistance to the part of the ball between x and K tended to press the ball *upwards*, that resistance above this line between x and V would tend to bury it still deeper; but as the whole of the arc x K would be greater than part of the arc x V, (H V being by hypothesis unburied,) arc x V would always cause most resistance; there would consequently be more than a balance of force to press it upwards, which would exist till the ball was wholly buried, but would then cease.

But, both in this case and in case 1, the ball is inclined to two modes of acting, either in going up the side, or out of the indentation; that is, by *rolling* or *sliding*, both of which would rob the ball of some of its force, by the friction produced, but the less should be the impediments which cause friction, the more would it be inclined to slide, and the more of them there should be, the more would it be inclined to *roll*, in its course, but even this would also rob the ball of some of its progressive force, and would be partly spent in giving a new motion (of rotation) to it, which would assist it to roll up the side of the ship, or to roll out of the indentation; but it must be particularly observed, that either the rotary motion of the ball, or the action of its curved surface in sliding, would tend to force the centre of the ball out of the indentation in the same manner, as it is easily to be perceived that the centre would describe the same curve, if it were to roll or to slide.

It is moreover evident, that *this* power of turning the ball from its direction, would be added to *that* derived immediately from the obliquity of the side, though this would be the cause of it all, or, in other words, the effect would be different (whatever was the hardness of the side) from what it would be if the ball were a mere point or flat body, acting against another flat oblique surface or indentation.

Case 3. If the force should be so great that the ball entirely buried itself, there would even then be two circumstances in favour of this construction; first, that the ball would have to perforate through a greater substance than if the side were perpendicular to the motion, the distance of which is shewn at H E fig. 1, and the oblique distance shewn at H O; and secondly, because the change of motion which would take place before the ball was quite buried, (as above described,) would still farther increase the length of substance to be perforated by it, and the course of the ball might be so much changed, that it should (after it was quite sunk) have to perforate the side through the remainder of its length upwards, instead of through its direct thickness.

It would be possible, however, for the balls to come in a perpendicular direction to the side, and to go through it directly, but it is improbable that this should frequently be the case; and it seems that it would be less likely to happen if it were fired at from a short distance, than from a great one, as then only a moderate elevation of the guns would be required, whereas, when the distance was small, the elevation would become so great, that it would be extremely difficult to take an aim so that the balls should come down upon it.

Neither of the cases, however, would altogether exist as described; but, as all substances possess a certain degree of hardness and elasticity, there would be a mixed effect produced, though I do not conceive the elasticity of wood to be sufficiently great to alter the cases materially; the results would therefore, it appears, be nearly as stated when the elasticity was not supposed to exist, but with some very sensible difference.

Since having made the preceding observations, I have tried the experiments relative to them on a small scale, and have found them precisely according to my idea. The side, fig. 1, was represented by a *deal* board, three-eighths of an inch thick, the return part W was of plate-iron, and the inside of the board S T was (perhaps improperly) coated with iron, the bullets were of lead, and about one-third part of the weight of a musket ball, and they were fired from a blunderbuss well charged; they made very slight long dents, not one-eighth inch deep in the deal, and when the additional board T S was not used, they flew upwards, and perforated the iron return part W; but when the board T S was added, they each made a dent also, near the narrow part I, and followed the return part W; and then they returned against a deal board placed behind the stock of the blunderbuss, and left moderately deep impressions on it.

I also made experiments on the plan of figs. 3, 4, and 5, though on a still smaller scale, and on a *deal* model, but with the same accordant results to the remarks I have made.

A thin coating of iron, on a wooden side, would not, I presume, be advantageous, as the iron would bend away from that part of the ball with which it should be in absolute contact, and the ball would then be improperly directed: therefore, whatever substance is employed, it should be of such a nature as to fit the ball as it goes, and the grain of the wood of which the side, &c. is made, should be in the direction of the motion of the ball, *not* transverse.

It is scarcely necessary to notice, that if the object of returning the ball be dispensed with, the side may simply be formed into a triangle C O P, figs. 3, 4, and 5, without the concave part N W A L; and, in fig. 1, without the return part W, and board T S, though the balls would be thrown more into the rigging by this means.

The lower part L should, perhaps, rather bend upwards, to cause the balls to fly a little upwards in returning, because those which come against the side H, figs. 3, 4, and 5, will not only be lowered the whole distance between H and L, but as they will return rather more slowly than they came, they will also be attracted downwards with more force by the power of gravity. The curve will likewise be more effective, if made smaller at the entry N L, than at the other part W A. I have also to add, that a coating of grease on the side, &c. is, it seems, of service.

But, I am fully aware, that however the experiments might have succeeded in miniature, the great force of a cannon-ball might defy them all, though it is known that slight obstructions affect their motion, when opposed to them obliquely. It also remains to be further tried, whether the balls would be returned with sufficient force.

Any person repeating these experiments, should (in order to avoid danger) stand at the side of the gun, at a great distance, and tie a string to the trigger, and of course must not place himself either behind or before it.

These observations are meant also to apply to fortifications, where, it seems, that the plan would be as effectual, or more so, than for ships.

FORTIN, Fortret, or *Field Fort*, a sconce or little fort, whose flanked angles are generally distant from one another 120 fathoms.

FOSS, in Fortification, a hollow place, commonly full of water, lying between the scarp and counterscarp, below the rampart; and turning round a fortified place, or a post that is to be defended.

Foss *Way*, one of the four principal highways of England, that anciently led through the kingdom, supposed to be made by the Romans, having a ditch upon one side.

FOSSIL, in Natural History, any thing dug out of the earth; and therefore fossils may be *native* or *extraneous:* the former shew no traces of organization; the latter are the remains of the vegetable and animal kingdoms; and these fossils are bones, shells, trees, leaves, &c. Numerous opinions are entertained of these organic remains; some authors maintaining that they are real stones, and stone plants, or bones; others, that they have been buried where they are now found, at the universal deluge. This seems the most natural opinion; for, in the tremendous convulsion of the whole mass of earth at the deluge, there is great reason to suppose that the various strata would range themselves according to their specific gravity, and bury in one general intermixture, earths, rocks, plants, quadrupeds, fishes, birds, and preserve them as we now find them, or at least give them those impressions they retain.

FOTHERING, a peculiar method of endeavouring to stop a leak in the bottom of a ship, while she is afloat either at sea or at anchor, which is performed by fastening a sail at the four corners, letting it down under the ship's bottom, and then putting a quantity of chopped rope yarn, oakum, wool, cotton, &c. between it and the ship's side; by repeating the latter part of this operation several times, the leak generally sucks in a portion of the loose stuff, and thereby becomes partly and sometimes wholly stopped. Some persons prefer thrumming the sail, instead of letting down the loose stuff, but in this mode the sail is soon chafed through by the hole, if the leak is considerable, without affording sufficient substance to stop it.

FOUL, a sea phrase, that is used in distinction to *clear*, and implies entangled, embarrassed. Hence, *Foul Anchor*, when the cable is twisted round the stock and flukes. *Foul Bottom*, when a bay is covered with weeds, grass, shells, filth, and rocks. *Foul Hawse*, means that the cables are turned round each other, by the ship having swung the wrong way when moored. *Foul Rope*, a rope entangled and unfit for immediate use. *Foul Water*, is water troubled and rendered turbid by the ship's bottom rubbing on the ground. *Foul Wind*, is used to express that the wind is unfavourable, or contrary to the ship's course, as opposed to large or fair.

FOUNDATION, in Architecture, is that part of a building which is under ground, and which Palladio makes as deep as one-fourth part the height of the whole building, unless there be cellars, when it may be somewhat lower.

Foundation, in ecclesiastical or political matters, is a donation or legacy in money or lands, for the maintenance or support of some charitable institution, as a hospital, a school, &c.

FOUNDER, To, to sink or go down. The fatal situation of a ship which is no longer able to keep above water, through accident, or the violence and continuation of a storm and the excess of the leaks, that fill her with water.

Founder, an artist who casts metals in various forms, for different uses as guns, bells, statues, printing characters, &c.

FOUNDRY, the place or art of casting all sorts of metals, as, a bell foundry, type foundry, &c. In casting types or letters, the two things principally to be regarded, are the *matter* and the *matrices*. The matter is a compound metal, partly copper, and partly lead, mixed in a certain proportion, which every letter-founder regulates at his own discretion, to this he adds a quantity of other metal, to render the composition harder. The matrices of the letters are pieces of copper about 1½ inch long, on which the impression of the intended character has been cut, or struck by puncheons, &c. graven in relievo. Each letter has its proper matrix: there are particular ones for points, figures, rules, head-pieces, and other ornaments of printing; the quadrats, being only of lead, and not intended to leave any impression, are cast in moulds without matrices; each matrice has its puncheon of steel, well-tempered. The matrices being struck, are put each at the end of an iron mould enclosed between two thin pieces of boards, three inches square; the two upper angles being cut off, so as to compose an irregular hexagon. Every thing belonging to the mould being disposed, the workmen begin to prepare the matter. The furnace, whereon the bason is placed for the metal to be melted in, is made of the same materials as crucibles. Over the furnace is placed the melting bason, or copper; divided into two equal parts, by a perpendicular partition, to melt either hard or soft metal. In this bason they melt only the matter already prepared; that is, the mixture or composition made in the crucibles. A small iron ladle serves to skim off from the melted metal the impurities, which are melted over again. Two workmen are employed at each furnace; they have a table on which they lay the characters as soon as they are cast; to run the metal into the mould, the founder holds in his ladle just enough for one letter. Having filled this ladle, he pours the metal through a funnel, into the matrix or character. He then opens the mould, and takes out the character; and without loss of time shuts it again, replaces the matrix, and casts a new letter. It is incredible with what expedition all this is done. The letter being cast, the workman views it before he breaks off the jet, to see whether it be perfect, otherwise he throws it among the refuse of the fount.

When the letters are composed, they remain to be *justified*, which is a very delicate operation, that embraces their being polished and squared by boys, and finished by the most expert workmen in the buisness. But it would exceed our limits to enter upon all the stages of this complicated operation here.

The excellence of types consists not only in the due performance of all the operations connected with their manufacture, but also in the hardness of the metal, the form and fine proportion of the character, and in the exact bearing and ranging of the letters in relation to one another. The smallest types are cast from an alloy of 25 parts of the regulus of antimony, and 75 of lead; the larger, 15 of antimony, and 85 of lead.

There are about twenty different sizes of types in general use, all of which are cast in moulds and matrices, besides several larger sorts, which are cast from patterns in sand. The following table gives the designation of the twenty sizes alluded to, and the spaces they occupy in printing. They are sold to the printers by the pound; the smallest being about 13 shillings and the largest about 2s. 2d. per lb.

	Lines to each Foot.		Lines to each Foot.
Diamond type contains..	204	Great Primer contains ..	61
Pearl, ...	178	Paragon, ...	44½
Nonparcil, ...	143	Double Pica, ...	41½
Minion, ...	128	2 line Pica, ...	35¾
Brevier, ...	112½	2 line English, ...	82
Bourgeois, ...	102	2 line Great Primer, ...	25½
Long Primer, ...	89	2 line Double Pica, ...	20¾
Small Pica, ...	83	Canons, ...	18
Pica, ...	71½	4 line Pica, ...	17¾
English, ...	64	5 line Pica, ...	14¼

By the common method of type founding, only a single letter is cast at a time, and the operation has been nearly the same for seventy years. A scheme was however set on foot about seventeen years ago, to enable the founder to cast a great number of letters at one time, thirty, or more, but it was not carried into practice by any of the founders. About the same time, Monsieur Didot, assisted by Mr. Donkin, the engineer, constructed a machine for a similar purpose; which was also intended to perform all the operations of the work, by the assistance of a boy only.

The invention which we have now to describe, is an improvement by Didot, upon his former highly ingenious machine, now rendered capable of casting 200 types at once, and to repeat the operation two or three times in a minute. A patent for this country has been taken out by Mr. J. L. Pouchée, who established a type foundry in Little Queen-street, Holborn, where the machinery was for some time in full and successful operation.

The number of drawings which accompany the specification of this patent obliges us to select such portions only as may best give a just idea of its construction, and we have for the same reason thrown the side views into perspective, which exhibits the machine entire, as at fig. 1. Fig 2 represents one side of the mould separated into its component parts. Fig. 3 is a section of the several bars, composing both sides of the mould.

Fig. 1.

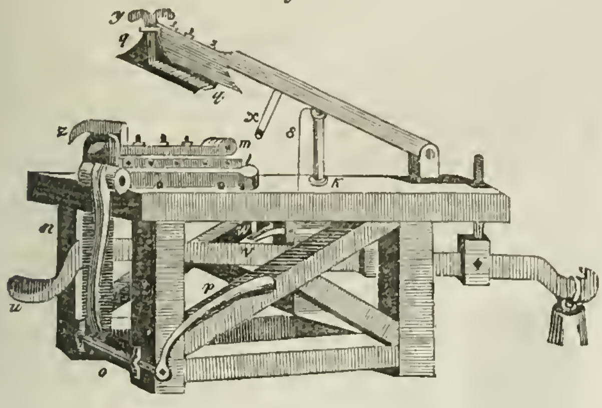


Fig 3.

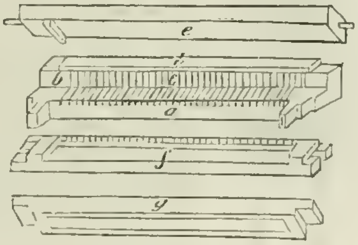


Fig. 2.

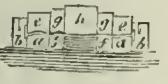


Fig. 4.

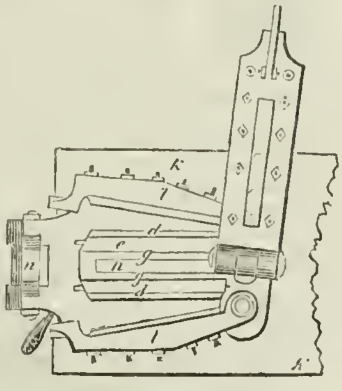


Fig. 4, exhibits a plan of the same, fitted into, and encompassed by a frame of iron, a horizontal and perspective view of which is given at fig. 1. The same letters refer to the same parts in each of the figures.

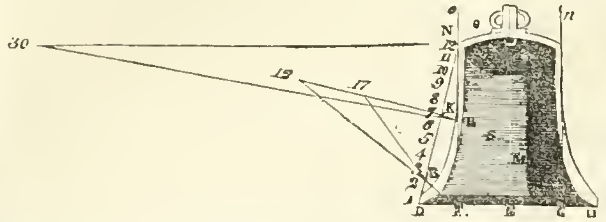
a fig. 3, is a steel bar, with horizontal grooves, in which are formed the bodies of the types; *b b* is the bar which holds the matrices *c c*, each of which is arranged opposite to its respective groove in the bar *a*, to which it is screwed fast; the bar *d* is then screwed down to the bar *b*, which holds the matrices *c c* firmly in their places. The bar *e* is next laid upon the bar *a*, which covers the grooves, and forms the upper sides of the square recesses, shewn also at *e e*, fig. 4;—*f* is the break-bar, and is placed in front of the bar *a*: a series of small nicks or openings are made in this bar, through which the fluid metal passes into the grooves and matrices, where the body and letter of the type is cast; the grooves are closed by the spaces between the nicks of the break-bar coming against them and forming the feet of the types. The bar *g* is laid upon the break-bar as a cover to it, and the whole six bars thus combined form one side, or one half of a pair of moulds, shewn in section, fig. 3. This section likewise exhibits the form of the apertures through which the fluid metal has to pass into the grooves and matrices; *h* is a receptacle between the moulds for the fluid metal, previous to its being forced into the moulds, as we shall presently discribe.

In preparing the moulds for casting, the several bars composing them are connected together as before mentioned, and, laid upon a solid metallic bed upon the table *k k*, as shewn at fig. 4; the sides of the iron frame *l l*, which turn upon joints, are then brought to bear sideways against the moulds; the top piece *m*, which also turns upon a joint, is brought down over the mould bars, which it firmly secures, by bringing the looped part of the swinging lever *n* shewn at fig. 1, over the end of the top piece *m*; which is effected by the aid of the hand lever *p*, forcing the tongue *o* against the lower end of the swinging lever, when the latch *z* falls and makes all fast. Thus prepared, a sufficient quantity of the fluid metal is poured out of a ladle into the receptacle between the moulds; a trigger at *r* is then pulled, when a string connected to it draws back a bolt or catch, *s*, which supports the long lever *t*, and allows it to fail with the rammer *q* into the receptacle, which drives with considerable force the fluid metal from thence into the moulds and matrices. On each side of the rammer *q* are fixed a guard or housing, to prevent the liquid metal from being splashed over the operator. In order to withdraw the types from the moulds, the workman places his foot upon the step *u*, when the compound lever *v* acts upon the pin *w*, under the leg *x*, and forces out the rammer from between the moulds, which is then lifted up by the workman until it has passed the catch *s*, which supports it in the positions shewn in the figure. The mould is then opened, by throwing up the hasp *z*; the swinging lever *n* then releases the end of the top piece, and allows the frame to be opened, and the moulds to be removed to a table, where the bars which compose it are placed under cramps, and separated by means of wrenches: the types are then removed, and undergo the operations of dressing, &c. as mentioned in the early part of our subject.—*Register of the Arts.*

Bell FOUNDRY. The metal of which bells are made is composed of three parts of copper and one of tin. The modern proportions for bells are to make the diameter fifteen times the thickness of the brim, and the height twelve times. The parts of a bell are: 1. The sounding bow, terminated by an inferior circle, which grows thinner and thinner. 2. The brim, or that part of a bell whereon the clapper strikes, and which is thicker than the rest. 3. The outward sinking of the middle of the bell, or the point under which it grows wider to the brim. 4. the waist, or furniture, and the part that grows wider and thicker quite to the brim. 5. The upper vase, or that part which is above the waist. 6. The pallet, which supports the stopper of the clapper within. 7. The bent and hollowed branches of metal uniting with the cannons, to receive the iron keys, whereby the bell is hung up to the beam, which is its support and counterpoise when rung out. In bell casting there are three processes: 1. The proportioning of the bell. 2. Forming the mould. 3. Melting the metal. The proportions of a bell are either simple or relative, the former gives it sonorosity, the latter establishes a requisite harmony between several bells.

The method of forming the profile of a bell, in which the proportion of the several parts are seen, is this:—The brim, C I, in the following figure, is the foundation of all the other measures, and is divided into three equal parts. Draw the line H D, which represents the diameter of the bell. Bisect it in F, and erect the perpendicular F *f*. Bisect D F and H F in E and G, at which draw perpendiculars E *e* and G *o*. G E will be the diameter of the top or upper vase, *i. e.* the diameter of the top will be half that of the bell; and it will therefore be the diameter of a bell that will sound an octave to the other. Divide the diameter of the bell, or the line H D, into 15 equal parts, and one of them will give C I the thickness of the brim. Divide again each of these 15 equal parts into three other equal parts, and then form your scale. From this scale take

12 of the larger divisions, or $\frac{2}{15}$ of the whole scale in your compasses, and setting one leg in D, describe an arc to cut the line Ee in N; draw N D, and divide this line into twelve equal parts; at the point 1 erect the perpendicular 1 C = 10, and C 1 will be the thickness of the brim = $\frac{1}{15}$ of the diameter. Draw the line C D, bisect D N, and at the point of bisection erect the perpendicular 6 K = $1\frac{1}{2}$ of the larger divisions on the scale. With an extent of compasses = 30 brims, (or twice the length of the scale,) setting one foot in N, describe an arc of a circle, and with the same leg in K, and the same opening, describe another arc to intersect the former. On this point of intersection as a centre, and with a radius = 30 brims, describe the arc N K; in 6 K produced, take K B = $\frac{1}{3}$ of the larger measure of the scale, or $\frac{1}{3}$ of the brim, and on the same centre with the radius of $30\frac{1}{3}$ brims, describe an arc A B parallel to N K. For the arc B C take 12 divisions of the scale, or 12 brims in the compass; find a centre, and from that centre, with this opening, describe the arc B C in the same manner as you did A B or N K. There are various ways of describing the arc Kp; some bell founders describe it on a centre at the distance of 9 brims from the points p and K; others, as we have done in the figure, on a centre at the distance only of 7 brims from those points. But it is necessary first to find the point p, and to determine the rounding of the bell p 1. For this purpose, on the point C as a centre, and with the radius C 1, describe the arc 1 p n. Bisect the part 1, 2 of the line D n, and erecting the perpendicular p m, this perpendicular will cut the arc 1 p n in m, which terminates the rounding 1 p. Some founders make the bendings K a third of a brim lower than the middle of the line D N; others make the part C I D more acute, and instead of making C 1 perpendicular to D N at 1, draw it $\frac{1}{6}$th of a brim higher, making it still = 1 brim; so that the line 1 D is longer than the brim C 1. In order to trace out the top part N a, take in the compasses eight divisions of the scale, or 8 brims, and on the points N and D as centers, describe arcs to intersect each other in 8; on this point 8, with a radius of 8 brims, describe the arc N b. This will be the exterior curve of the top or crown. On the same point 8 as a centre, and with a radius = $7\frac{2}{3}$ brims, describe the arc A e, and this will be the interior curve of the crown, and its whole thickness will be $\frac{1}{3}$ of the brim. As the point 8 does not fall in the axis of the bell, a centre M may be found in the axis, by describing with the interval of 8 brims on the centres D and H, arcs which will intersect in M; and this point may be made the centre of the inner and outer curves of the crown, as before. The thickness of the cap which strengthens the crown at Q, is about $\frac{1}{3}$ of the thickness of the brim, and the hollow branches or ears, about $\frac{1}{6}$th the diameter of the bell. The height of the bell in proportion to its diameter, is as 12 to 15, or in the proportion of the fundamental sound to its third major, whence it follows, that the sound of a bell is principally composed of the round of its extremity, or brim, as a fundamental of the sound of the crown, which is an octave to it, and of that of the height, which is a third.

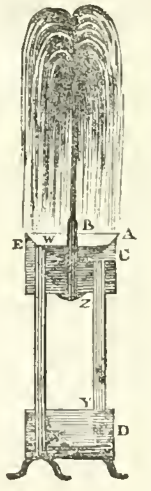


The particulars of moulding and casting are to be best learned in the workshop; as the former is either simple or complicated, according to the inscriptions, coats of arms, &c. designed to be put on the bell.

FOUNT, or FONT, among Printers, &c. a set of types, sorted for use, that includes running letters, large and small capitals, single letters, double letters, points, commas, lines, numerals, &c. as a fount of English, of Pica, Bourgeois, &c. A fount of 100,000 characters, which is a common fount, would consist of 5000 types of *a*, 3000 of *c*, 11,000 of *e*, 6000 of *i*, 3000 of *m*, and about 30 or 40 of *k*, *x*, *y*, and *z*. But this is only to be understood of the lower-case types; those of the upper case having other proportions, which we need not here enumerate. Also a fount of 10 sheets would print 80 pages of this Dictionary without distributing a single letter, and it would weigh 120 lbs. per sheet, or 1200 lbs. in all, which at 2*s*. 6*d*. per lb. would amount to £150. 0*s*. 0*d*. Now, if there were two dozen founts in an office, the reader may form some idea of the capital necessary to carry on a large business in printing, including presses, and all the numerous expenses contingent on this most popular and most useful profession.

FOUNTAIN, or ARTIFICIAL FOUNTAIN, in Hydraulics, a machine or contrivance by which water is violently spouted or darted up; called also a *Jet d'Eau*. There are various kinds of artificial fountains, but all formed by a pressure of one sort or another upon the water; *viz*. either the pressure or weight of a head of water, or the pressure arising from the spring and elasticity of the air, &c. When these are formed by the pressure of a head of water, or any other fluid of the same kind with the fountain, or jet, then will this spout up nearly to the same height as that head, abating only a little for the resistance of the air, with that of the adjutage, &c. in the fluid rushing through; but, when the fountain is produced by any other force than the pressure of a column of the same fluid with itself, it will rise to such a height as is nearly equal to the altitude of a column of the same fluid, whose pressure is equal to the given force that produces the fountain.

Circulating FOUNTAIN, or *Fountain of Hero of Alexandria*, so called because it was contrived by him, is represented thus:— The air being only compressed by the concealed fall of water, makes a jet, which, after some continuance, is considered, by those who are unacquainted with the principle, as a perpetual motion, because they imagine that the same water which fell from the jet rises again. The boxes C E and D Y X, being close, we see only the bason A B W, with a hole at W, into which the water spouting at B falls; but that water does not come up again; for it runs down through the pipe W X into the box D Y X, from which it drives out the air, through the ascending pipe Y Z, into the cavity of the box C E, where, pressing upon the water that is in it, it forces it out through the spouting pipe O B, as long as there is any water in C E; so that this will play no longer than whilst the water contained in C E, having spouted out, falls down through the pipe W X into the cavity D Y X. The force of the jet is proportional to the height of the pipe W X, or of the boxes C E and D Y above one another: the height of the water, measured from the bason A B W to the surface of the water in the lower box D Y X, is always equal to the height measured from the top of the jet to the surface of the water in the middle cavity at C E. *See* the article JET D'EAU, in which this subject is fully handled.



FOURTEENTH, in Music, the octave, or replicate, of the seventh. A distance comprehending thirteen diatonic intervals.

FOURTH, in Music, a distance comprising three diatonic intervals, or two tones and a half.

FOWLING, the art of taking or killing birds. It is either practised as an amusement by persons of rank and property, and then principally consists in killing them with a fowling piece, and the diversion is secured to them by the game laws; or it is practised for a livelihood, by persons who use nets and other apparatus. Fowling was formerly used for the pursuing and taking birds with hawks, more properly called Falconry.

FOWLING *Piece*, a light gun for shooting birds. That piece is always reckoned best which has the longest barrel, from $3\frac{1}{2}$ to 6 feet, with a moderate bore; though every fowler should have them of different sizes, suitable to the game he designs to kill. The barrel should be well polished and smooth within, and the bore of an equal bigness from one end to the other, which may be proved by putting in a piece of pasteboard, cut of the exact roundness of the top; for if this goes down without stops or slipping, you may conclude the bore good.

FRACTION is a part or parts of the unit, and written with two figures, with a line between them, as $\frac{1}{4}$, $\frac{5}{8}$, $\frac{3}{8}$, &c. The figure above the line is called the *numerator*, and the under one the *denominator;* which shews how many parts the unit is divided into; and the numerator shews how many of those parts are meant by the fraction. There are four sorts of Vulgar Fractions; *proper, improper, simple, compound* and *mixed*, viz.

A *Proper* FRACTION, is when the numerator is less than the denominator, as $\frac{3}{4}$, $\frac{3}{5}$, $\frac{7}{8}$, $\frac{9}{11}$, $\frac{101}{701}$, &c.

An *Improper* FRACTION, is when the numerator is equal to, or greater than the denominator, as $\frac{5}{3}$, $\frac{4}{4}$, $\frac{12}{12}$, $\frac{187}{8}$, &c.

A *Simple* FRACTION, is that which consists of a single numerator, and single denominator; and is either proper, or improper, as $\frac{5}{7}$, $\frac{11}{7}$, $\frac{16}{81}$, &c.

A *Compound* FRACTION, is a fraction consisting of two or more other fractions connected by the word *of*; thus $\frac{2}{3}$ of $\frac{3}{4}$, or $\frac{3}{4}$ of $\frac{7}{11}$ of $\frac{6}{9}$, &c. are compound fractions.

A *Complex* FRACTION, is that whose numerator and denominator are both fractions;

thus $\dfrac{\frac{3}{4}}{7\frac{1}{2}}$ is a complex fraction. These two distinctions, though frequently made by authors on arithmetic, are certainly improper, the former indicating an operation in multiplication, and the latter an operation in division; it is, therefore, improper to apply to them the denomination of fractions. An integer and fraction together is called a mixed number, that is, $7\frac{3}{4}$, $9\frac{1}{3}$, &c. are mixed numbers.

Reduction of FRACTIONS.—1. To reduce fractions to a common denominator.—*Rule* 1. Multiply each numerator into all the denominators, except its own, for a new numerator; and all the denominators, for a common denominator. Or, 2. Multiply the common denominator by the several given numerators separately, and divide the product by their several denominators; the quotients will be the new numerators.

Example. Reduce $\frac{2}{4}$ and $\frac{4}{7}$ to a common denominator.

Ans. $\frac{14}{28}$, and $\frac{16}{28}$.

$2 \times \overset{\text{nm.}}{7} = 14$, $4 \times \overset{\text{2d num.}}{4} = 16$, then $4 \times 7 = 28$ den. $= \frac{14}{28}$, and $\frac{16}{28}$.

2. To reduce a vulgar fraction to its lowest terms.—*Rule.* Find a common measure by dividing the lower term by the upper, and that divisor by the remainder following, till nothing remains; the last divisor is the common measure; then divide both parts of the fraction by the common measure, and the quotient will give the fraction required. If the common measure happens to be 1, the fraction is already in its lowest term; and when a fraction hath ciphers at the right-hand, it may be abbreviated by cutting them off; as, $\frac{24|0}{111|0}$.

Example. Reduce $\frac{24}{32}$ to its lowest terms.

24)32(1
24
com. measure 8)24(3 then 8)$\frac{24}{32}$($= \frac{3}{4}$ *Ans.*
24

3. To reduce a mixed number to an improper fraction.—*Rule.* Multiply the whole number by the denominator of the fraction, and to the product add the numerator for a new numerator, which place over the denominator. To express a whole number fraction-ways, set one for the denominator given.

Example. Reduce $18\frac{3}{7}$ to an improper fraction. *Ans.* $\frac{129}{7}$.

$\overline{18 \times 7} + 3 = 129$, new numerator.

4. To reduce an improper fraction to its proper terms.—*Rule.* Divide the upper term by the lower.

Example. Reduce $\frac{129}{7}$ to its proper terms. *Ans.* $18\frac{3}{7}$.

$129 \div 7 = 18\frac{3}{7}$.

5. To reduce a compound fraction to a single one.—*Rule.* Multiply all the numerators for a new numerator, and all the denominators for a new denominator. Reduce the new fraction to its lowest terms by *Rule* 2.

Example. Reduce $\frac{2}{3}$ of $\frac{3}{5}$ of $\frac{5}{8}$ to a single fraction.

$\dfrac{2 \times 3 \times 5 = 30}{3 \times 5 \times 8 = 120}$ reduced to the lowest term $= \frac{1}{4}$. *Ans.*

6. To reduce fractions of one denomination to the fraction of another, *but greater*, retaining the same value.—*Rule.* Reduce the given fraction to a compound one, by comparing it with all the denominations between it and that denomination which you would reduce it to; then reduce that compound fraction to a single one.

Example. Reduce $\frac{7}{8}$ of a penny to the fraction of a pound.

Ans. $\frac{7}{8}$ of $\frac{1}{12}$ of $\frac{1}{20} = \frac{7}{1920}$.

7. To reduce fractions of one denomination to the fraction of another, *but less*, retaining the same value.—*Rule.* Multiply the numerator by the parts contained in the several denominations between it and that you would reduce it to, for a new numerator, and place it over the given denominator. Reduce the new fraction to its lowest terms.

Example. Reduce $\frac{7}{1920}$ of a pound to the fraction of a penny.
$7 \times 20 \times 12 = 1680$, $\frac{1680}{1920}$ reduced to its lowest term $= \frac{7}{8}$. *Ans.*

8. To reduce fractions of one denomination to another of the same value, having the numerator given of the required fraction.—*Rule.* As the numerator of the given fraction is to its denominator, so is the numerator of the intended fraction to its denominator.

Example. Reduce $\frac{2}{3}$ to a fraction of the same value, whose numerator shall be 12. As 2 : 3 :: 12 : 18. *Ans.* $\frac{12}{18}$.

9. To reduce fractions of one denomination to another of the same value, having the denominator given of the fraction required.—*Rule.* As the denominator of the given fraction is to its numerator, so is the denominator of the intended fraction to its numerator.

Example. Reduce $\frac{2}{3}$ to a fraction of the same value, whose denominator shall be 18. As 3 : 2 :: 18 : 12. *Ans.* $\frac{12}{18}$.

10. To reduce a mixed fraction to a single one.—*Rule.* When the numerator is the integral part, multiply it by the denominator of the fractional part, adding in the numerator of the fractional part for a new numerator; then multiply the denominator of the fraction by the denominator of the fractional part for a new denominator.

Example. Reduce $\dfrac{36\frac{2}{3}}{48}$ to a simple fraction. *Ans.* $\frac{110}{144} = \frac{55}{72}$.

$36 \times 3 + 2 = 110$ numerator.
$48 \times 3 \qquad = 144$ denominator.

When the denominator is the integral part, multiply it by the denominator of the fractional part, adding in the numerator of the fractional part for a new denominator; then multiply the numerator of the fraction by the denominator of the fractional part for a new numerator.

Example. Reduce $\dfrac{47}{65\frac{3}{5}}$ to a simple fraction. *Ans.* $\frac{235}{328}$ = [illegible]

11. To find the proper quantity of a fraction in the known parts of an integer.—*Rule.* Multiply the numerator by the common parts of the integer, and divide by the denominator.

Example. Reduce $\frac{3}{4}$ of a pound sterling to its proper quantity. Here $3 \times 20 = 60$, and $\div 4 = 15$*s.* *Ans.*

12. To reduce any given quantity to the fraction of any greater denomination, retaining the same value.—*Rule.* Reduce the given quantity to the lowest term mentioned for a numerator, under which set the integral part (reduced to the same term) for a denominator, and it will give the fraction required.

Example. Reduce 15*s.* to the fraction of a pound sterling.—Here 15*s.* are 15 parts of 20*s.* or $\frac{15}{20}$ which reduced to the lowest, gives $\frac{3}{4}$£. *Ans.*

Addition of FRACTIONS.—*Rule.* Reduce the given fractions to a common denominator, then add all the numerators together, under which place the common denominator.

Example. Add $\frac{2}{3}$ and $\frac{5}{7}$ together. $\frac{14}{21} + \frac{15}{21} = \frac{29}{21} = 1\frac{8}{21}$. *Ans.*

When the fractions are of several denominations, reduce them to their proper quantities, and add as before.

Example. Add $\frac{3}{4}$ of a pound to $\frac{5}{6}$ of a shilling.

Here $\frac{3}{4}$£. $= \frac{3}{4}$ of $\frac{20}{1} = \frac{60}{4} =$ 15*s.* 0*d.* }
and $\frac{5}{6}$*sh.* $= \frac{5}{6}$ of $\frac{12}{1} = \frac{60}{6} =$ 0*s.* 10*d.* } *Ans.* £0. 15*s.* 10*d.*

Subtraction of FRACTIONS.—*Rule* 1. Reduce the given fractions to a common denominator, then subtract the less numerator from the greater, and place the remainder over the common denominator. 2. When the lower fraction is greater than the upper, subtract the numerator of the lower fraction from the denominator, and to that difference add the upper numerator, carrying one to the unit's place of the lower whole number.

Example I. From $\frac{3}{4}$ take $\frac{5}{7}$.

$3 \times 7 = 21,\ 5 \times 4 = 20,\ 21 - 20 = 1$ numerator.
$4 \times 7 = 28$ denominator $= \frac{1}{28}$ *Ans.*

2. From $5\frac{2}{3}$ take $\frac{9}{10}$. *Ans.* $4\frac{23}{30}$.
3. From $\frac{38}{47}$ take $\frac{3}{5}$. *Ans.* $\frac{49}{235}$.
4. From $\frac{19}{20}$ take $\frac{1}{7}$ of $\frac{2}{3}$. *Ans.* $\frac{359}{420}$.

When the fractions are of several denominations, reduce them to their proper quantities, and subtract as before.

Ex. From $\frac{3}{4}$ of a pound take $\frac{3}{4}$ of a shilling. *Ans.* 14*s.* 3*d.*

$$\left.\begin{array}{l} \text{Here } \tfrac{3}{4}\text{£. of } \dfrac{20s.}{1} = \dfrac{3 \times 20}{4} = \dfrac{60}{4} = 15s.\ 0d. \\ \text{And } \tfrac{3}{4} \text{ of } \dfrac{12}{1} = \dfrac{3 \times 12}{4} = \dfrac{36}{4} = \quad 0 \quad 9 \end{array}\right\} \begin{array}{c} \textit{Answer.} \\ \text{£0. } 14s.\ 3d. \end{array}$$

Multiplication of FRACTIONS.—*Rule.* Prepare the given numbers, (if they require it,) by the rules of Reduction; then multiply the numerators together for a new numerator, and the denominators for a new denominator. When any number, either whole or mixed, is multiplied by a fraction, the product will be always less than the multiplicand, in the same proportion as the multiplying fraction is less than the unit.

Example. Multiply $\frac{3}{4}$ by $\frac{3}{5}$.
Ans. $3 \times 3 = 9$ num. $4 \times 5 = 20$ den. $= \frac{9}{20}$.

Division of FRACTIONS.—*Rule.* Prepare the given numbers, (if they require it,) by the rules of Reduction; then multiply the denominator of the divisor into the numerator of the dividend for a new numerator, and the numerator of the divisor into the denominator of the dividend for a new denominator. When any whole number is divided by a fraction less than unity, the quotient will be greater than the dividend: but if any fraction be divided by a whole number greater than unity, the quotient will be less than the dividend.

Ex. Divide $\frac{9}{20}$ by $\frac{3}{5}$. $5 \times 9 = 45$ num. $3 \times 20 = 60$ den. $\frac{45}{60} = \frac{3}{4}$.

The Rule of Three in FRACTIONS.—*Rule.* When the three terms are properly reduced, proceed as in the Rule of Three in whole numbers.

Example 1. If $\frac{3}{4}$ of a yard cost $\frac{5}{8}$ of a £.—what will $\frac{9}{10}$ of a yard come to at that rate? *Ans.* $\frac{18}{24} = 15s.$

$\frac{3}{4}$ yd. : $\frac{5}{8}$ £. : : $\frac{9}{10}$ yd. : : $\frac{18}{24}$ £.

$$\begin{array}{l} \text{for } 4 \times 5 \times \ \ 9 = 180 \text{ num.} \\ \text{and } 3 \times 8 \times 10 = 240 \text{ den.} \end{array} \text{ or } \tfrac{5}{8} \times \tfrac{9}{10} = \tfrac{45}{60} \quad \tfrac{3}{4}\,)\,\tfrac{45}{80}\,(\,\tfrac{15}{20}.$$

Example. 2. If 48 men can build a wall in $24\frac{1}{4}$ days—how many men can do the same in 192 days? Thus

$$\frac{192}{1} : \frac{97}{4} : : \frac{48}{1} : \frac{1 \times 97 \times 48}{192 \times 4 \times 1} = \frac{97}{4 \times 4} = \frac{97}{16} = 6\tfrac{1}{16} \text{ men.}$$

The Double Rule of Three in FRACTIONS.—This is stated in the same manner as in common arithmetic.

Example. If a carrier receive $2\frac{1}{10}$£. for the carriage of 3 cwt. 150 miles—how much ought he to receive for the carriage of 7 cwt. $3\frac{1}{2}$ qrs. for a journey of 50 miles?

$$\begin{array}{lcccccccccc} & \textit{qrs.} & & \textit{miles.} & & \text{£.} & & & & & \\ \text{Thus} & \dfrac{150}{1} & : & \dfrac{21}{10} & : : & \dfrac{50}{1} & : & \dfrac{1 \times 21 \times 50}{150 \times 10 \times 1} & & & \\ \text{and} & \dfrac{12}{1} & : & \dfrac{1050}{1500} & : : & \dfrac{63}{2} & : & \dfrac{1 \times 1050 \times 62}{12 \times 1500 \times 2} & = \dfrac{441}{240} = & \begin{array}{ccc} \text{£} & s. & d. \\ 1 & 16 & 9 \end{array} \end{array}$$

FRACTURE, in Surgery, the rupture of a bone, or a solution of continuity in a bone, when it is crushed or broken by some external cause.

FRÆNUM, in Anatomy, a term applied to some membranous ligaments of the body.

FRÆNUM *Linguæ*, the ligament under the tongue, which sometimes ties it down too close to the bottom of the mouth, and then requires to be divided, to give this organ its proper motion.

FRAGARIA, the *Strawberry*, a genus of the polygynia order, in the icosandria class of plants, and in the natural method ranking under the 35th order, senticosæ, which all thrive in any common garden soil, producing abundant crops annually without much trouble.

FRAME. *See* SPINNING.

FRANCHISE, in Law, synonymous to liberty—"a royal privilege, or branch of the king's prerogative, subsisting in the hands of a subject," say the expounders of the law. Franchises may be vested in either natural persons or bodies politic; in one man, or in many; as of a county palatinate, a corporation, &c., of which each individual has by right or prescription the *freedom*. Other franchises are to hold a court leet, to have a manor or lordship, a bailiwick, fair, market, toll, &c.

FRANK FEE, in Law, signifies the same thing as holding lands and tenements in fee-simple.

FRANK *Pledge*, in our Law, signifies a pledge or surety for the behaviour of freemen.

FRANK, or *Franc*, an ancient coin of gold or silver, current in France. The value of the gold frank was somewhat more than that of the gold crown; the silver frank was a third of the gold one. Silver franks are now the current coin in France, and all accounts are kept in francs and centimes, according to the decimal system. There are 20 sols to a franc, and sometimes sols still appear in small accounts. It is usually said that 24 franks, or 480 sols, are equivalent to a pound sterling, but the real par is about 25 francs to a pound sterling.

FRANKS, or *Franking Letters*, by which they are forwarded free of postage, is a privilege that has been enjoyed by members of parliament from the first institution of the post-office. A member of parliament can frank only ten letters a day, and receive fifteen, free of postage; each of which must weigh less than one ounce. It is felony to forge a frank.

FRANKINCENSE, is the product of the juniperus lycia.

FRANKLIN, BENJAMIN, a celebrated American philosopher and politician, was born at Boston, in New England, in the year 1706. He was author of several tracts on electricity and other branches of natural philosophy, and was the first who drew electricity from a thunder cloud. But his knowledge, however eminent as a philosopher, is eclipsed by his fame as a politician, in which latter character he forms an excellent subject for the general biographer and historian. Dr. Franklin died April 17, 1790, being then in the 84th year of his age.

FRAPPING, the act of crossing and drawing together the several parts of a tackle, or other complication of ropes, which had already been strained to their utmost extent; in this sense, it exactly resembles the operation of bracing up a drum. The frapping increases tension, and consequently adds to the security acquired by the purchase; hence the catharpings are no other than the frappings to the shrouds.

FRAPPING *of a Ship*, the act of passing four or five turns of a cable-laid rope, round the hull or frame of a ship in the middle, when it is apprehended that she is not strong enough to resist the violent efforts of the sea. This expedient is only made use of for very old ships, which their owners are willing to venture to sea as long as possible by insuring them deeply.

FRAUD. All deceitful practices in defrauding, or endeavouring to defraud, another of his own right, by means of some artful device, contrary to the plain rules of common honesty, are condemned by the common law, and punishable according to the heinousness of the offence. The distinction laid down, as proper to be attended to in all cases of this kind is this, that in such impositions or deceits, where common prudence might guard persons from the offence, it is not indictable, but the party is left to his civil remedy; but where false weights or measures are used, or false tokens produced, or such measures taken to defraud or deceive, as people cannot by any ordinary care or prudence be guarded against, there it is an offence indictable. Persons convicted of obtaining money or goods by false pretences, or sending threatening letters to extort money or goods, may be punished by fine and imprisonment, or by pillory, whipping, or transportation, 30 G. II. c. 24.

FRAXINUS, the *Ash*, a genus of the diœcia order, in the polygamia class of plants, and in the natural method ranking under the 44th order sepiariæ. There are four species, of which the most useful is the common ash. This tree flourishes best in groves, but grows very well in rich soil, in open fields. It bears transplanting and lopping. In Lancashire, they lop the tops of these trees to feed the cattle in autumn. The wood is hard and tough, and is much used to make the tools employed in husbandry. The ashes of the wood afford good potash. The bark is used in tanning calf skin.

FREE Bench, signifies that estate in copyhold which the wife, being espoused a virgin, has after the decease of her husband for her dower, according to the custom of the manor.

FREEDOM of Corporation, the right of enjoying all the privileges and immunities that belong to it. The freedom of cities and corporations is regularly obtained by serving an apprenticeship; but it is also purchased with money, and sometimes conferred by way of compliment.

FREEHOLD, *Frank Tenement*, is land or tenement which a man holds in fee-simple, fee-tail, or for term or life; and is of two kinds, in *deed* and in *law*, the first being real possession of land or tenement, in fee, fee-tail, or for life; the other, is the right a man has to such land or tenement before his entry or seizure.

FREEING, the act of pumping, or otherwise throwing out the water which has leaked into a ship's bottom at sea, &c.

FREESTONE, a whitish stone dug up in many parts of England, that works like alabaster, but is more hard and durable, being of excellent use in building, &c.

FREEZE, or Frieze, in Commerce, a coarse kind of woollen stuff or cloth, so called, as being freezed or naped on one side.

FREEZING, Congelation, in Philosophy, the transformation of a fluid body into a firm or solid mass, by the action of cold; in which latter sense the term is applied to water when it freezes into ice; to metals when they resume their solid form after being melted by heat; or to glass, wax, pitch, tallow, &c. vhen they harden again after having been rendered fluid by ieat. *See* Congelation and Evaporation.

The process of congelation is always attended with the mission of heat, as is found by experiments on the freezing of vater, wax, spermaceti, &c.; for in such cases it is always ound that a thermometer dipped into the fluid keeps continually descending as this cools, till it arrives at a certain point, being the point of freezing, which is peculiar to each fluid, where it is rather stationary, and then rises for a little, while the congelation goes on, at the same time the bulk of the body s expanded.

The prodigious power of expansion evinced by water in the act of freezing is nearly double that of the most powerful steam-engines, and exerted in so small a mass, seemingly by the force of cold, was thought a very material argument in favour of those who supposed that cold, like heat, is a positive substance. Dr. Black's discovery of latent heat, however, has afforded an easy and natural explication of this phenomenon. He has shewn that, in the act of congelation, water is not cooled more than it was before, but rather grows warmer: that as much heat is discharged, and passes from a latent to a sensible state, as, had it been applied to water in a fluid state, would have heated it to 135°. In this process the expansion is occasioned by a great number of minute bubbles suddenly produced. Formerly these were supposed to be cold in the abstract; and to be so subtile, that insinuating themselves into the substance of the fluid, they augmented its bulk, at the same time that by impeding the motion of its particles upon each other, they changed it from a fluid to a solid. But these are only air extricated during the congelation; and to the extrication of this air we ascribe the prodigious expansive force exerted by freezing water. By what means does this air come to be extricated, and to take up more room than it naturally does in the fluid? Perhaps part of the heat, which is discharged from the freezing water, combines with the air in its unelastic state, and, by restoring its elasticity, gives it that extraordinary force, as is seen also in the case of air suddenly extricated in the explosion of gunpowder.

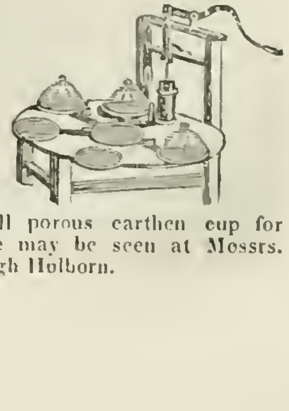
The greatest degrees of heat which are known, have been produced by concentrating the solar rays with a mirror, or lens, or by supplying a blow-pipe with oxygen gas. A very great degree of cold is produced by mixing snow with certain salts. The best salt for this purpose is muriate of lime. If this be mixed with dry, light snow, and stirred well together, the cold produced will be so intense, as to freeze mercury in a few minutes. Salt and snow also produce a great degree of cold. Evaporation likewise produces cold. The method of making ice artificially in the East Indies, depends upon this principle. The manufacturers at Benares dig pits in large open plains, the bottom of which they strew with sugar-canes, or dried stems of maize, or Indian corn. Upon this bed they place a number of unglazed pans, made of so porous an earth, that the water oozes through their substance. These pans are filled towards evening, in the winter season, with water which has been boiled, and are left in that situation till morning, when more or less ice is found in them, according to the temperature of the air; there being more formed in dry and warm weather, than in cloudy weather, though it may be colder to the human body.

Every thing in this operation is calculated to produce cold by evaporation; the beds on which the pans are placed, suffer the air to have a free passage to their bottoms, and the pans constantly oozing out water to their external surface, are cooled by the evaporation of it. In Spain, they use a kind of earthen jars, called buxaros, the earth of which is so porous, being only half-baked, that the outside is kept moist by the water which filters through it; and, though placed in the sun, the water in the jar becomes as cold as ice. It is a common practice in China, to cool wine or other liquors by wrapping a wet cloth round the bottle, and hanging it up in the sun. The water in the cloth evaporates, and thus cold is produced. Ice may be produced at any time by the evaporation of ether.

Freezing *Mixture*, a preparation for the artificial congelation of water and other fluids. The first person who made experiments on freezing mixtures was Fahrenheit. But the subject was much more completely investigated by Mr. Walker, in a paper published in the Philosophical Transactions for 1795. Since that time several curious additions have been made by professor Lowitz, particularly the introduction of muriate of lime, which produces a very great degree of cold when mixed with snow; and the experiments of Lowitz have been lately repeated and extended by Mr. Walker. In the Philosophical Transactions for 1801, p. 135, is given a table, divided into classes; in the first rank of these classes of mixtures, Mr. Walker has not specified the temperature at which the materials were, previous to mixing; the reader being informed, in a paragraph which immediately follows the table, that it is immaterial, the result being the same as stated in the table, whatever may be the temperature of the materials at mixing. So that it is not requisite to specify the temperatures at which it was supposed to be necessary the materials should be, previous to mixing, in order to produce the effects stated.

Professor Leslie has lately discovered that porphyritic trap, pounded and dried, will absorb one-tenth part of its weight of moisture, and can hence be easily made to freeze the eighth part of its weight of water. In hot countries the powder will after each process recover its power by drying in the sun. This curious and beautiful discovery of artificial congelation, will therefore produce ice in the tropical climes, or even at sea, with very little trouble, and no sort of risk or inconvenience. Thus we are convinced of the wonderful power of chemistry. This one discovery, which enables man in the hottest climate, even in the torrid zone, to compose artificially, and by such a simple process, the product of the frigid zones, is but a single instance, but it is sufficient to rank that noble science among one of the most important to man. Even in our every-day meals, our tea, our coffee, every process of cookery, of medicine, in short, almost all the operations of nature and art, are carried on by the means either of chemical, electric, or magnetic processes, with all of which we may become acquainted in some degree.

The annexed figure represents a large air pump, for the purpose of freezing, on Leslie's principle. It consists of a stout low frame, in which a good air pump is fixed, and on the plate are six receivers, each furnished with a broad glass saucer for holding sulphuric acid, or pounded whinstone, and a small porous earthen cup for holding the water. The machine may be seen at Messrs. Harris's, the opticians, No. 50, High Holborn.



Leslie has lately discovered that parched oatmeal is even a more powerful absorbent than the whinstone; and with a stratum of oatmeal, about a foot diameter, and one inch deep, he froze a pound and a quarter of water, contained in a hemispherical porous cup. The meal is easily dried, and restored to its former use.

Freezing *Point*, denotes the point or degree of cold, shewn by a mercurial thermometer, at which certain fluids begin to freeze, or, when frozen, at which they begin to thaw again. On Fahrenheit's thermometer this point is at + 32 for water, and at — 40 for quicksilver, these fluids freezing at those two points respectively. *See* Thermometer.

Freezing *Rain*, or *Raining* Ice, a very uncommon kind of shower, which fell in the west of England, in December, 1672, of which we have various accounts in the Philosophical Transactions. This rain, as soon as it touched any thing above ground, as a bough, &c. immediately settled into ice; and, by multiplying and enlarging of the icicles, broke all down with its weight. The rain that fell on the snow immediately froze into ice, without sinking in the snow at all. It made an incredible destruction of trees, beyond any thing recorded in history. "Had it concluded with some gust of wind, (says a gentleman on the spot,) it might have been of terrible consequence. I weighed the sprig of an ash tree, of three-quarters of a pound, the ice on which weighed 16 pounds. Some were frightened with the noise in the air, till they discerned it was the clatter of icy boughs, dashed against each other." This phenomenon, however, is not uncommon in a less degree, and depends wholly on the nice balance of temperatures in the rain and atmosphere. Dr. Beale observes, that there was no considerable frost observed on the ground during the whole; whence he concludes, that a frost may be very intense and dangerous on the top of some hills and plains; while in other places it keeps at two, three, or four feet distance above the ground, rivers, lakes, &c. and may wander about very furious in some places, and remiss in others not far off. This frost was followed by glowing heats, and a wonderful forwardness of flowers and fruits.

Freeze, in Naval Architecture, ornamental painting or sculpture on the upper part of a ship's quarter, stern, or bow. It consists generally of armour, instruments of war, marine emblems, &c.

FREIGHT of a Ship, the hire of part thereof, usually paid for the carriage and conveyance of goods; or the sum agreed upon between the owner and the merchant for the hire and use of a vessel.

Freight. The freight of a vessel is usually agreed on either at the rate of so much for the voyage, or by the month, or per ton.

FREIGHTING, or *Letting out Vessels on Freight or Hire*, was once one of the principal branches of the trade of the Dutch. They were the carriers of all the nations of Europe, and their purveyors, notwithstanding that their country produced little or nothing, and that they were forced to have every thing necessary for the building of a vessel from other countries. The principal laws relating to freighting are:—That if a whole vessel be hired, and the merchant, or person who hires it, does not give it its full load or burden, the master of the vessel cannot, without his consent, take in any other goods without accounting to him for freight. That, though the merchant do not load the full quantity of goods agreed on in the charter-party, yet he shall pay the whole freight; and if he load more, he shall pay for the excess. If a time be appointed by charter-party, and either the ship be not ready to take in, or the merchant to put on board, the parties are at liberty, with remedy by action for the detriment. If part be on board, and some misfortune prevent the merchant's lading the whole in time, the master may contract with another, and have freight as damage for the time longer than limited. On the other hand, if the vessel be ready, the merchant may ship the remainder of the goods aboard another, and recover damages against the first master or owners; therefore, by the marine law, chance, or other notorious necessity, will excuse the master, but he loses his freight till he breaks ground. But if the merchant be in fault, he must answer the damage, or be liable to maintain the crew ten days; and if after that, the full freight: if damage afterwards, it is the merchant's risk: but by the common law, while the goods are on board, the master must see them forthcoming. If goods are fully laded, and the ship has broken ground, but the merchant afterwards declines the adventure, and unlades again, by the maritime law the freight is due. If a set time be agreed on between the merchant and master to begin and end the voyage, it may not be altered by the supercargo without special commission; and if a master shall sail on his voyage after the time agreed on for his departure, and damage happens afterwards, he shall make it good. If a ship be freighted from one port to another, thence to a third, &c. and so home to the port whence she first sailed, (commonly called a trading voyage,) the whole is one and the same voyage, if performed according to the charter-party. If the ship be freighted out and in, no freight is due till the voyage is performed; if, therefore, the ship perish coming home, the whole freight is lost.

The master may set ashore such goods as he finds in his vessel which were not notified to him, or take them at a higher rate than was agreed on for the rest. But if the master freight his ship, and afterwards secretly take in other goods, he loses his freight; and if any of the freighter's goods should, for the ship's safety, be cast overboard, the rest shall not be subject to average, but the master must make it good.

If a ship be stopped or detained in its course, either through the master's or merchant's default, the delinquent shall be accountable to the other. Thus, if the freighter load the ship with prohibited goods, he shall answer the freight contracted; but if the ship put into any other port than she is freighted to, the master shall answer damage to the merchant; but if forced in by storm, enemy, or pirates, he must then sail to the stipulated port at his own costs. If the master be obliged to refit his vessel during his voyage, the merchant shall wait, or else pay the whole freight; if the vessel could not be refitted, the master is obliged to hire another immediately, otherwise only to be paid his freight in proportion to the part of the voyage performed; though, in case the merchant prove that the vessel, at the time it set sail, was not capable of the voyage, the master must lose his freight, and an account for damages to the merchant. Freight shall be paid for merchandises which the master was obliged to sell for victuals, or refitting, or other necessary occasions, paying for the goods at the rate the rest were sold at where they were landed. In case of a prohibition of commerce with the country whither the vessel is bound, so that it is obliged to be brought back again, the master only shall be paid freight for going. And if a ship be stopped or detained in its voyage by an embargo by order of the prince, there shall neither be any freight paid for the time of the detention in case it be hired per month, nor shall the freight be increased, if hired for the voyage; but the pay and the victuals of the sailors during the detention, shall be deemed average.

Freight is also used for the burden or lading of a ship, or the cargo of goods, &c. which she has on board. Freight is also a duty paid to the government of France by the masters of foreign vessels going in or out of the several ports of the kingdom.

It is to be observed, that all vessels not built in France are accounted foreign, though belonging to that government, and as such, are liable to the payment of an impost, unless otherwise exempted, or that two-thirds of the crew are French. The Dutch and the Hanse Towns were exempted from the duty of freight.

FRENICLE, Bernard, a celebrated French mathematician of the seventeenth century, contemporary and companion of Descartes, Fermet, Roberval, and the other distinguished mathematicians of that time.

FRESCO, a method of painting in relievo on walls, so as to endure the weather. It is performed with water colours on fresh plaster; or a wall laid with mortar not dry. This sort of painting has a great advantage, by its incorporating with the mortar with which it dries.

FRESH, when applied to the wind, signifies strong, but not violent or dangerous; hence, when the gale increases, it is said to *freshen*.

Fresh *Shot*, signifies the falling down of any great river into the sea, by means whereof the sea hath fresh water a good way from the mouth of the river. As this is more or less, they call it a great or small fresh shot.

Fresh *Spell*, a fresh gang to relieve the rowers in the long-boat. Fresh *Water*, implies water fit to drink, in oppostion to sea or salt water. Fresh *Way of a Ship* implies considerable velocity.

To Freshen *Hawse*, to relieve that part of the cable which has for some time been exposed to friction in one of the hawse-holes, when the ship rocks and pitches at anchor in a high sea; this is done by applying fresh service to the cable within board, and then veering it into the hawse.

Freshes, imply the impetuosity of an ebb-tide increasing by heavy rains and flowing out into the sea, which it often discolours to a considerable distance from the shore, insomuch as the line which divides the two colours may be perceived distinctly for a great length along the coast.

FRET, or Fretto, in Architecture, a kind of ornament, consisting of two lists or fillets interlaced, and running at parallel distances equal to the breadth.

Fret, in Music, a kind of stop on some instruments, particularly bass-viols and lutes.

FRIABILITY, that quality of certain bodies whereby they are easily reduced to powder. Thus we speak of the friability of earths, &c.

FRICTION, the act of rubbing two bodies together, or the resistance in machines caused by the motion of the different parts against each other. Friction arises from the roughness or asperity of the surface of the body moved on, and that of the moving body; for such surfaces consisting alternately of small eminences and cavities, these act against each other, and prevent the free motion that would ensue, on a supposition of the two bodies being perfectly polished planes.

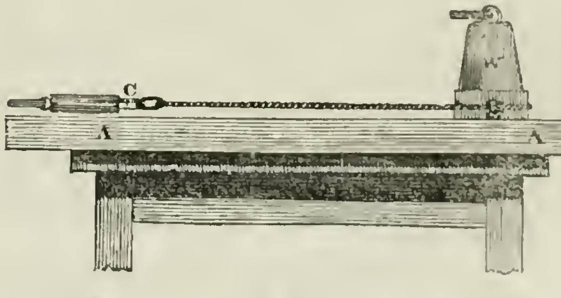
Mr. Ferguson found that the quantity of friction was always proportional to the weight of the rubbing body, and not to the quantity of surface; and that it increased with an increase of velocity, but was not proportional to the augmentation of celerity. He found also that the friction of smooth soft wood, moving upon smooth soft wood, was equal to one-third of the weight; of rough wood upon rough wood, one-half of the weight: of soft wood upon hard, or hard upon soft, one-fifth of the weight; of polished steel upon polished steel or pewter, one-quarter of the weight; of polished steel upon copper, one-fifth; and of polished steel upon brass, one-sixth of the weight.

Columb has made numerous experiments upon friction, and by employing large bodies and ponderous weights, and conducting his experiments on a large scale, he has corrected several errors which necessarily arose from the limited experiments of preceding writers; he has brought to light many new and striking phenomena, and confirmed others which were hitherto but partially established.

We cannot in a work of this kind follow M. Columb through his numerous and varied experiments; all that can be expected will be a short abstract of the most interesting of his results; a few of which are as follow:—1. The friction of homogeneous bodies, or bodies of the same kind moving upon each other, is generally supposed to be greater than that of heterogeneous bodies; but Columb has shewn that there are exceptions to this rule. 2. It was generally supposed that in the case of wood, the friction is greatest when the bodies are drawn contrary to the course of their fibres; but Columb has shewn that the friction in this case is sometimes the smallest. 3. The longer the rubbing surfaces remain in contact, the greater is their friction. 4. Friction is in general proportional to the force with which the rubbing surfaces are pressed together, and is commonly equal to between one-half and one-quarter of that force. 5. Friction is not generally increased by augmenting the rubbing surfaces. 6. Friction is not increased by an increase of velocity, at least it is not generally so; and even in some cases the friction decreases with an increase of celerity. 7. The friction of cylinders rolling upon an horizontal plane is in the direct ratio of their weights, and in the inverse ratio of their diameters.

From a variety of experiments on the friction of the axes of pulleys, Columb also obtained the following results;—When an iron axle moved in a brass bush or bed, the friction was one-sixth of the pressure; but when the bush was besmeared with very clean tallow, the friction was only one-eleventh; when swine's grease was interposed, the friction amounted to $\frac{1}{8 \cdot 5}$; and when olive-oil was employed as an unguent, the friction was never less than $\frac{1}{8}$, or $\frac{1}{7 \cdot 5}$. When the axis was of green oak, and the bush of guaiacum-wood, the friction was $\frac{1}{26}$ when tallow was interposed; but when the tallow was removed, so that a small quantity of grease only covered the surface, the friction was increased to $\frac{1}{17}$. When the bush was made of elm, the friction was of similar circumstances $\frac{1}{33}$ and $\frac{1}{20}$, which is the least of all. If the axis be made of box, and the bush of guaiacum-wood, the friction was $\frac{1}{23}$ and $\frac{1}{14}$, circumstances being the same as before. If the axle be of box wood, and the bush of elm, the friction will be $\frac{1}{29}$ and $\frac{1}{20}$; and if the axle be of iron, and the bush of elm, the friction will be $\frac{1}{20}$ of the force of pressure. In wood rubbing upon wood, oil, grease, or black-lead, properly applied, makes the friction two-thirds less. Wheel-naves, when greased, have only one-fourth of the friction they would have if wet. Hence the propriety of so contriving wheel naves as to keep the grease from being dissipated. When polished steel moves on steel, or pewter properly oiled, the friction is about one-fourth of the weight; on copper or lead, one-fifth; on brass, one-sixth; and metals have more friction when they move on metals of the same kind, than on different metals. The friction of a single lever is very little. The friction of the wheel and axle is in proportion to the weight, velocity, and diameter of the axle; the smaller the diameter of the axle, the less the friction. The friction of pulleys is great, on account of the smallness of their diameters in proportion to that of their axes; because they often bear against the blocks, and from the wearing of their holes and axles. In the wedge and screw there is much friction. Screws with sharp threads have more friction than those with square threads, and endless screws have most.

An easy method of experimenting on the friction of surfaces, is, to place a plank with its upper surface level; and on this a thin block of the matter to be tried, with a cord fixed to it, which block may be loaded with different weights; and a spring steelyard attached to the other end of the cord, to draw it along by, will shew the force necessary to produce motion. See the following figure, where A A is the plank, B the block of matter to be tried loaded with a weight W, C the scale of the spring steelyard; which shews the force required to overcome the friction, when the block B is moved by drawing at the hook D. By attending to a few precautions, the friction of surfaces may be easily ascertained with this simple apparatus. Thus, to try the friction of white deal on white deal, the plank A A was of that substance, as well as the block B. Then a weight W was put on the block, when the block and the load upon it amounted to 20 lbs. The force required to move it from rest, as shewn by the steelyard, was 7 lbs.; and when there was 20 lbs. more weight laid upon the block, the force to move it was 14 lbs., hence we find that the friction increases in the same proportion as the weight. In making the experiment on the friction of wood, the block moves quickly forward as soon as you have gently drawn the spring to the measure of its friction at rest, and it may be continued in gentle motion with a less degree of force. Now, if you continue to draw steadily, so as to give the block the slowest regular motion it will take, the scale will shew the friction in motion to be 3½ lbs. when



the load is 20 lbs., and 7 lbs. when the load is 40 lbs.; therefore the friction in motion is not sensibly different from being proportional to the pressure.

The relation between the friction and the pressure is—20 : 7 :: 100 : 35; that is, the friction from rest is 35 lbs. when the pressure is 100 lbs. or 35 per cent. in white fir on white fir, drawn in the direction of the grain of the wood, when the rubbing surfaces of the fir have been planed true and even. And the friction of white fir on white fir, in motion, is, 40 : 7 :: 100 : 17½, or 17½ lbs. when the pressure is 100 lbs. that is, 17½ per cent.

In trying the friction in motion, the slowest regular movement should be obtained. If you endeavour to produce a quicker motion, you will find that a greater force is necessary; because it requires more force to give a body a greater velocity than a small one, though the friction be the same. Without this explanation, a very wrong measure of friction might be adopted.

The friction from rest of white fir on white fir, across the grain, is not quite 33 lbs. when the pressure is 100 lbs.: but when in motion, the friction is sensibly different from that in the direction of the grain.

The surface of the block in the preceding trial was six square inches, and when it was reduced to three square inches, the same results were obtained. In these trials there was no attempt made to ascertain to what extent it was possible to reduce the rubbing surfaces without increasing the friction.

To try the friction of metals at a small expense, let the blade saw be laid flat on the plank A A, and a small piece of metal, with one of its faces ground true, will serve for the moving piece B. If the moving piece B be of steel, the surfaces will then be steel on steel, and the friction from rest is sensibly the same as the friction in motion; *i. e.* 20 lbs. when the pressure was 100 lbs., or the friction one-fifth of the pressure. When the piece B was of cast iron, ground true and even, the friction was 22 lbs. when the surfaces were pressed together by 100 lbs. and it was sensibly the same at the first moving from rest, as to continue a slow motion. When the piece B was of gun-metal,* ground true and even, the friction was only 15½ lbs. when the pressure was 100 lbs. and the same in slow motion as from rest.

From these experiments it will appear, that the friction of different combinations of matter differ very considerably; and that an immense quantity of power may be lost in a machine by using those substances for the rubbing parts which have great friction. We see that in a combination, where gun-metal moves against steel, the same weight may be moved with a force of 15½ lbs., which it would require 22 lbs. to move when cast iron moves against steel.

The resistance, called friction, performs important offices in nature and in works of art. Friction destroys, but never generates motion. Were there no friction, all bodies on the surface of the earth would be clashing against one another: rivers would dash with unbounded velocity, and we should see little besides collision and motion. As it is, whenever a body acquires a great velocity, it soon loses it by friction against the surface of the earth; the friction of water against the surfaces it runs over, soon reduces the rapid torrent to a gentle stream; the fury of the tempest is lessened by the friction of the air on the face of the earth; and the violence of the ocean is subdued by the attrition of its own waters. Its offices in works of art are equally important.

Our garments owe their strength to friction; and the strength of ropes, sails, and various other things, depends on the same cause; for they are made of short fibres, pressed together by twisting, and this pressure causes a sufficient degree of friction to prevent the fibres sliding one upon another. Without friction, it would be impossible to make a rope of the fibres of hemp; or a sheet of the fibres of flax; neither could the short fibres of cotton have ever been made into such an infinite variety of forms as they have received from the hands of our truly ingenious countrymen. Wool also has been converted into a thousand textures for comfort or for luxury, and all these are constituted of fibres, united by friction. In fine, if friction retards the motion of machines, and consumes a large quantity of moving power, we have a full compensation in other, and equally necessary, benefits which it insures to us.

Friction, in Medicine and Surgery, the act of rubbing the surface of the body, whether with the hand only, with the flesh-brush, flannel, or other substances, or with oils, ointments, or other medicinal matters, with a view to the preservation of health, or to the removal of particular diseases. In delicate habits the use of the flesh-brush, or gentle rubbing with the hand, until some degree of glow is produced on the surface of the skin, may contribute, like riding or other species of exercise, to support or improve the health. The wholesome effects of friction are well illustrated by the advantages of currying horses; the benefits derived from it in these animals are generally considered as equivalent to half the feeding.—Friction is an efficacious remedy in several conditions of disease; particularly in chronic rheumatisms of long standing; in muscular contractions, succeeding to rheumatism, &c. and connected often with effusions of lymph; in some states of paralysis; in certain indolent tumours, &c. In these cases, a variety of unguents and liniments is recommended; but the friction itself is the principal source of relief.

FRIENDLY Societies, denote associations, chiefly among the most industrious of the lower and middling class of tradesmen and mechanics, for the purpose of affording each other relief in sickness; and their widows and children some assistance at their death. These have been thought worthy of the protection of the legislature, to prevent frauds which had arisen from the irregular principles on which many of them were conducted. The statute 33 Geo. III. c. 54, provides, that any number of persons may form themselves into a society, and raise among themselves a fund for their mutual benefit, and make rules and impose fines. The rules, declaring the purpose for which such societies are established, are to be exhibited to the quarter sessions, who may annul or confirm them; in which latter case, they are to be signed by the clerk of the peace. No rule thus confirmed is to be altered but at a general meeting of the society, and subject to the control of the sessions.

FRIEZE, in Architecture, that part of the entablature of columns between the architrave and corniche. Anciently friezes were enriched with figures of animals; in modern times, they are commonly ornamented by figures in basso relievo.

FRIGATE, in the Navy, a light nimble ship, built for the purpose of sailing swiftly. These vessels mount from twenty to forty-four guns, and make excellent cruisers.

Frigate-*built*, the disposition of the decks of such merchant ships as have a descent of four or five steps from the quarter-deck and forecastle into the waist, in contradistinction to those whose decks are on a continued line for the whole length of the ship, which are called galley-built. Formerly the name of frigate was only known in the Mediterranean, and applied to a kind of long vessels navigated in that sea with sails and oars. The English were the first who appeared on the ocean with those ships, and equipped them for war as well as commerce.

FRIGORIFIC Particles, is a term used by some early philosophers to denote what they considered the matter of cold, as modern philosophers make caloric the matter of heat.

FRINGELLA, in Ornithology, a genus belonging to the order of passeres, of which there are one hundred and three species, distinguished principally by varieties in their colour, as the carduelis, or goldfinch. 2. The cælebs, or chaffinch. 3. The montifringilla, or brambling. 4. The domestica, or sparrow. 5 The spinus, or siskin. In the bird-shops in London it is known by the name of the aberdavine. It is a docile species, and is often kept and paired with the canary-bird, with which it breeds freely. 6. The linota, or linnet. 7. The cannabina, or greater redpole, which frequents our sea-coasts, and is often taken near London. 8. The linaria, or lesser redpole, is known about London by the name of stone redpole. 9. The montium, or twite, about the size of a linnet. 10. The canaria, or canary-bird, originally peculiar to those islands, to which it owes its name. These birds are all well known.

FRIT, in the Manufacture of Glass, is the matter or ingredients of which the glass is to be made, when they have been calcined or baked in a furnace; and these ingredients are soda and sand or flint.

---

* A composition of copper and tin used for bearings in machinery.

FRITH, an arm of the sea, as the frith of Forth, the frith of Clyde, &c.

FRIZING, in the Woollen Manufactories, is a term applied to the forming of the knap of cloth or stuff into any number of little hard burrs or prominences, covering almost the whole ground thereof. Some cloths are only frized on the back, as black cloths; others on the right side, as coloured and mixed cloths, rateens, bays, freezes, &c. Frizing may be performed two ways; one with the hand, that is, by two workmen, who conduct a kind of plank that serves for a frizing instrument. The other way is by a mill, worked either by water or a horse, or sometimes by men. This latter is esteemed the better way of frizing, the motion being uniform and regular, and the little knobs of the frizing are formed more equably and regularly.—The structure of this useful machine is as follows: The three principal parts are, the frizer or crisper; the frizing-table; and the drawer, or beam. The two first are two equal planks, or boards, each about 10 feet long, and 15 inches broad; differing only in this, that the frizing-table is lined or covered with a kind of coarse woollen stuff, of a rough, sturdy knap, and that the frizer is incrustated with a kind of cement composed of glue, gum-arabic, and yellow sand, with a little aqua vitæ, or urine. The beam or drawer, thus called because it draws the stuff from between the frize and frizing-table, is a wooden roller, beset all over with little, fine, short points or ends of wire, like those of cards used in carding of wool. The disposition and use of the machine are thus; the table stands immoveable, and bears or sustains the cloth to be frized, which is laid with that side uppermost on which the knap is to be raised. Over the table is placed the frizer, at such a distance from it as to give room for the stuff to be passed between them; so that the frizer, having a very slow, semicircular motion, meeting the long hairs or knap of the cloth, twists and rolls them into little knobs or burs, while, at the same time, the drawer, which is continually turning, draws away the stuff from under the frizer, and winds it over its points.

FROG-FISH of Surinam, a singular animal, which is produced by the transformation of a frog into a fish. In Surinam these fishes are called jakies. They are cartilaginous, of a substance like our mustela, and exquisite food. They are formed with regular vertebræ, and small bones all over the body, divided into equal parts; are first darkish, and then gray; their scales make a beautiful appearance.

FROST, such a state of the atmosphere as causes the congelation or freezing of water or other fluids into ice. In the more northern parts of the world, even solid bodies are affected by frost, though this is only or chiefly in consequence of the moisture they contain, which being frozen into ice, and so expanding, as water is known to do when frozen, it bursts, and rends any thing in which it is contained, as plants, trees, stones, and large rocks. Many fluids expand by frost, as water, which expands about one-tenth part, for which reason ice floats in water; but others again contract, as quicksilver, and thence frozen quicksilver sinks in the fluid metal. Frost, being derived from the atmosphere, naturally proceeds from the upper parts of bodies downwards, as the water and the earth; so the longer a frost is continued, the thicker the ice becomes upon the water in ponds, and the deeper into the earth the ground is frozen.

FROTH SPIT, or Cuckow Spit, a name given to a white froth or spume very common in the spring. It forms the nidus of a species of cicada.

FRUCTIFICATION, the terminating of an old vegetable, and the beginning of a new successor. *See* Botany.

FRUIT, in Botany, is that part of a plant in which the seed is contained; and *fruits* are *recent*, *fresh*, and *dry*, according as they have been gathered for immediate use, or prepared for keeping, by being dried in the sun, or otherwise preserved.

Fruit *Stones* swallowed, have often been the cause of fatal complaints in the bowels; for though the guts are so defended by their proper mucus, that people, and children especially, seldom suffer by the generality of things they devour; yet the hair off the skins of animals, the stumps of birds' feathers, the fibres, vessels, and nerves of plants, are not altered by the stomach, and often collect in lumps in the intestines, producing colics, pains, &c. without being voided, except by the most violent purges.

FRUSTUM, in Geometry, is the part of a solid next the base, left by cutting off the top or segment by a plane parallel to the base; as the frustum of a pyramid, of a cone, of a conoid, of a spheroid, or of a sphere, which is any part comprised between two parallel circular sections; and the middle frustum of a sphere is that whose ends are equal circles, having the centres of the sphere in the middle of it, and equally distant from both ends.

FUCUS, a name given by the ancients to certain dyes and paints. By this name they called a purple sea-plant, used by them to dye woollen and linen cloths of that colour. The dye was very beautiful, but not lasting; for it soon began to change, and in time went wholly off.

Fucus, in Botany, a genus of the order of algæ, belonging to the cryptogamia class of plants; as, 1. The serratus, serrated fucus, or sea-wrack, frequent upon the rocks at low-water-mark. 2. The vesiculosus, bladder fucus, common sea-wrack, or sea-ware, grows on the sea-rocks about low-water-mark. This species is an excellent manure for land; to which purpose it is often applied in Scotland, and other countries. But the most beneficial use to which the fucus vesiculosus is applied, is in making kelp, a work much practised in the Western isles. The manufacture or burning of kelp employs 30,000 persons in Great Britain, and it sells from £4. 10*s*. to £5. 5*s*. a ton.

FUEL, comprehends the fluid inflammable bodies; peat or turf; charcoal of wood; pit-coal charred; and wood, or pit-coal in a crude state, and capable of yielding a copious and bright flame.

FUGUE, in Music, a term derived from the Latin *fuga*, a flight, and signifying a composition either vocal or instrumental, or both, in which one party leads off some determined succession of notes called the subject, which, after being answered in the fifth and eighth by the other parts, is interspersed through the movement, and distributed amid all the parts at the pleasure of the composer, sometimes accompanied by other adventitious matter, and sometimes by itself. There are distinct descriptions of fugues; the simple fugue, the double fugue, and counter fugue.

FULCRUM, in Mechanics, the prop or support upon which a lever is sustained. *See* Lever.

FULGORA, or Lantern Fly, an insect belonging to the hemiptera order. 1. The Peruvian lantern-fly measures nearly three inches and a half from the front to the tail, and about five inches and a half from wing to wing, when expanded; this beautiful insect is a native of Surinam, and many other parts of South America, and during the night diffuses so strong a splendour from its head, that it may be employed for the purpose of a candle or torch; and it is said, that three or four of the insects tied to the top of a stick, are frequently used by travellers for that purpose. 2. The fulgora candelaria is a smaller species than the preceding, and is a native of China. 3. Fulgora diadema is an Indian species; its colour is brown, with red and yellow variegations; in size it is nearly similar to that of the preceding species.

FULICA, the *Gallinule* and *Coot*, a genus of birds of the order of gallæ, of which there are 25 species, 18 of which belong to the gallinule division, distinguished by having the toes furnished with broad scalloped membranes; and seven comprehend the coots, which have the toes divided to their origin. The atra, or common coot, has a bald forehead, a black body, and lobated toes, and is about 15 inches in length. They frequent lakes and still rivers; making their nests among the rushes, with grass, reeds, &c. floating on the water, so as to rise and fall with it.

FULL and By, the situation of a ship with regard to the wind, when she is close-hauled, and sailing in such a manner as neither to steer too nigh the direction of the wind, nor to deviate from it; or it is when a ship is as close as she will lie to the wind without suffering the sails to shiver; hence, *Keep her Full*, is the order to the helmsman, not to incline too much to windward, and thereby shake the sails, which would retard the ship's velocity.

FULLER, a workman employed in the woollen manufac tories to mill or scour cloths, serges, and other stuffs, in order to render them more thick, compact, and durable.

FULLER'S Earth, a well-known mineral, generally of a greenish white colour, more or less mixed with brown, gray, or yellow; of a soft and friable texture, and somewhat unctuous to the touch. When thrown into water, it immediately absorbs it, and breaks down into a fine pulp. Its great utility in removing grease from woollen cloths, and other fabrics, has given this earth a great value in commerce, and its exportation is prohibited under very severe penalties. There are very extensive beds of this earth in several counties in England, as Kent, Surrey, Sussex, and at Wavedon, near Woborn, in Bedfordshire. In no country in the world is such excellent fuller's earth produced as at Wavedon. We have noticed the valuable property of this earth, of taking grease out of woollen and other cloths, which, on a large scale, is effected by the operation called fulling, whence its name has been derived. This, which is performed by a kind of water-mill, called a fulling-mill, is particularly necessary with respect to new cloths, for the purpose of depriving them of the grease and oil which has been used in their preparation.

In the dressing of cloth, this earth is so indispensable, that foreigners, although they can procure the wool, are never able, without fuller's-earth, to reach the perfection of the English cloths; and in this country incalculable quantities of it are consumed. As an article of domestic utility, it might be more frequently used than it is for the cleaning and scouring of wooden floors and wainscots. In this respect it might be rendered an excellent substitute for soap. *See* Woollen Cloths.

FULLING, the act of cleansing, scouring, and pressing, stuffs, cloths, stockings, &c. to render them stronger, firmer, and closer; called also *milling*, because these cloths are in fact scoured by a *water mill*. The principal parts of a *fulling-mill* are, the wheel with its trundle, which gives motion to the tree or spindle, whose teeth communicate that motion to the pestles or stampers, which fall into troughs, wherein the cloth is put with fuller's earth to be scoured, and thickened by this process of beating it.

FULMINATING Powder, (from *fulmino*, to *thunder*,) is a prepared powder which explodes upon the application of certain degrees of heat, with instantaneous combustion and prodigious loud noise.

Simple fulminating powder, without any metallic substance, is thus prepared; take three parts of nitre, two of purified pearl-ash, and one of flowers of sulphur; mix the whole very accurately in an earthen mortar, and place it on a tile or plate before the fire till it is perfectly dry; then transfer it while hot into a ground stopper bottle, and it may be kept without injury for any length of time. In order to experience its effects, pour from ten to forty grains into an iron ladle, and place it over a slow fire; in a short time the powder becomes brown, and acquires a pasty consistence; a blue lambent flame then appears on the surface, and in an instant after the whole explodes with a stunning noise and a slight momentary flash. If the mass be removed from the fire as soon as it is fused, and kept in a dry well-closed vial, it may at any time be exploded by a spark, in which case it burns like gunpowder, but more rapidly and with greater detonation; but this effect cannot be produced on the unmelted powder, how accurately soever the ingredients of it are mixed together. When fulminating powder is in fusion, but not heated to the degree necessary to produce the blue flame, a particle of ignited charcoal thrown upon it will occasion immediately a remarkably loud explosion. It appears, that the ingredients of this powder do not acquire their fulminating property till combined by fusion; in other words, till the potash of sulphur form sulphuret of potash; whence fulminating powder may also be made by mixing sulphuret of potash with nitre, instead of by adding the sulphur and alkali separate. In all these, the cause of the detonation or fulmination is not accurately understood. In simple fulminating powder, there is a very large portion of elastic gas evolved; in fulminating gold or silver, a much smaller; yet the explosion in the latter case is infinitely greater than that in the former.

Fulminating Gold. Dissolve pure gold into muriatic acid to saturation, and dilute the solution with three times its bulk of distilled water, and add to it gradually some pure ammonia; a yellow precipitate will be obtained, which must be repeatedly washed with distilled water, and dried on a chalk stone, or in a filter. When dry, it is called fulminating gold, and detonates by heat, as may be shewn by heating a few grains of it on the point of a knife over the candle.

Fulminating Silver. Dissolve fine silver in pale nitric acid, and precipitate the solution by lime water; decant the fluid, mix the precipitate with liquid ammonia, and stir it till it assumes a black colour; then decant the fluid, and leave it in the air to dry. This product is fulminating silver, which cannot even be touched without producing a violent explosion. Its preparation is so hazardous, that it ought not to be attempted without a mask, with strong glass eyes, upon the face. No more than a single grain ought at any time to be tried as an experiment.

Mr. Chenevix has invented a less dangerous fulminating silver, which is thus prepared: Diffuse a quantity of alumina through water, and let an abundant current of chlorine gas pass through it. Then digest some phosphate of silver on the solution of the chlorate of alumina, and evaporate it slowly. The produce will then be a hyperchlorate of silver, a single grain of which, in contact with two or three of sulphur, will explode violently with the slightest friction.

Fulminating Mercury. The mercurial preparations which fulminate when mixed with sulphur, and gradually exposed to a gentle heat, are well known to chemists; they were discovered by Mr. Bayen.

Mercury, and most, if not all its oxides, may, by treatment with nitric acid and alcohol, be converted into a whitish crystallized powder, possessing all the inflammable properties of gunpowder, as well as many peculiar to itself.

FUNCTION, Animal, applied to the actions of the body, is by physicians divided into vital, animal, and natural. The vital functions are those necessary to life, and without which the individual cannot subsist; as the motion of the heart, lungs, &c. The natural functions are those which the body cannot subsist any considerable time without, as the digestion of the aliment and its conversion into blood. Animal functions include the senses of touching, tasting &c. memory, judgment, and voluntary motion.

Function. A quantity is said to be a function of another quantity, when its value depends on that quantity and known quantities only; and it is said to be a function of several quantities, when its value depends on those quantities and known quantities only.

FUNDAMENTAL Note, in Music, the principal note in a song or composition, to which all the rest are adapted: it is also called the key to the song.

FUNDS, the Public, in a political sense, mean the money lent by the nation to government, and known as the *National Debt*, and for which the lenders, or their assignees, receive interest from revenues allotted for that purpose. For upwards of a century past, the war expenses of the government have far exceeded the produce of the taxes; hence the government has been compelled to borrow on the security of the taxes on property; and the accumulated national debt, at the present time, is estimated at about 830 millions, for the re-payment of which, and its interest, 31 millions, all the property of the country, stands mortgaged. The interest of this debt is regularly paid at the Bank of England from the produce of the taxes. Hence it is that persons who have spare money either gladly subscribe to loans, or purchase of public creditors their shares of the public debt, called *Stock*. There are several kinds of stock or funds, according to the annual interest, as, 3 per cent. stock; 3½ per cent. stock; and 4 per cent. stock.

To purchase stock, or to put money in the stocks, is to become a *creditor* of the nation, by buying a title to so much interest. Of course, the price of stock varies according as money is more or less plentiful, as there are more or fewer buyers, and as the opinion of public credit is high or low. As £100 produces 5 per cent. at lawful interest, the 4 per cent. is at par at £80; the 3½ at £70; and the 3 per cent. at £60. The stocks are high or low, as they produce less or more than legal interest, and as they vary above or below par.

Sinking Fund. In order to pay off the national debt, Dr. Price suggested, in 1786, an expedient of reserving a million per annum, with which to purchase stock for the public, and to apply all its interest in further purchases, so that the fund should increase in the ratio of compound interest. Upwards of three hundred thousand per annum was afterwards added, and the whole called *The Sinking Fund*. A farther plan of repayment was adopted in 1792, of appropriating one pound of every hundred borrowed in future, to the same principle of accumulation, it being known that one pound at compound interest will produce £99 in 94 years, or £60, the par price of the 3 per cents. in 84 years. The accumulation of these various means had enabled the public commissioners on the 1st of February, 1814, to redeem 234 millions of the debt, to buy up, and to make annual purchases of upwards of eleven millions, so that the whole of the present debt may be redeemed by these means within forty years; supposing, as was actually done in 1823, that five or six millions annually can be appropriated to this fund.

The expenses of the government, or the *supplies* required of parliament, amounted, in 1814, to nearly 120 millions per annum, of which 28 millions were for the navy; 39 millions for the army and ordnance; 33 millions for the interest of the national debt; and the rest for the civil list and miscellaneous. During the year ending January 5, 1822, the public expenditure was above 21 millions, of which five millions and a half were for the navy, and nine millions and a quarter for the army and ordnance, two millions for the civil list, &c. and five millions for interest of exchequer bills and sinking fund, over and above the interest of the public debt, amounting to 31 millions.

The *ways* and *means* for raising the above supplies are, by duties of customs and excise; by assessed taxes, by stamp and legacy duties, and by licenses of various kinds.

FUNGI, the name of the 4th order of the 24th class of vegetables, in the Linnæan system, comprehending the mushroom kind. This order in Linnæus contains 10 genera. The ancients called fungi children of the earth, to indicate the obscurity of their origin. The moderns have likewise been at a loss in what rank to place them; some referring them to the animal, some to the vegetable, and others to the mineral kingdom. Messrs. Wilck and Munchausen have not scrupled to rank them in the number of animal productions; because when fragments of them, or their seed, were macerated in water, they perceived a quantity of animalcules discharged, which they supposed capable of being changed into the same substance.

The mushroom is one of the most perishable of plants, and therefore the most favourable for the generation of insects. Considering the quickness of its growth, it must be furnished with a power of copious absorption; the extremities of its vessels must be more dilated than in other plants. Its root seems in many cases to be merely intended for its support; for some species grow upon stones or moveable sand, from which it is impossible that they can draw much nourishment. We must therefore suppose, that it is chiefly by the stalk that they absorb. These stalks grow in a moist and tainted air, in which float multitudes of eggs, so small, that the very insects they produce are with difficulty seen by the microscope. A quantity of these eggs are probably absorbed by the vessels of the fungus, and remain there without any change, till the plant begins to decay.

FUNGUS, in Surgery, denotes any spongy excrescence.

FUNICULAR Machine, is a term used to denote an assemblage of cords, by means of which two or many powers sustain one or many weights. This is classed by some authors among the simple mechanical powers, and is the simplest of them all. In order to find the law of equilibrium in this machine, we must first reduce all the powers which meet at one point to a single power, by the method of composition of forces; which single power must act in the direction of the cord, this being evidently necessary for establishing an equilibrium; following this method, we may reduce all the powers which act on different points of the cord, to a system of powers acting on the same point. Then to establish the perfect equilibrium, reduce these powers, which act all on the same point, to one equivalent power, and we shall have two powers only, which ought to be equal, and acting in contrary directions.

FUR, in Commerce, the skin of a wild beast dressed in alum, with the hair on; and used as part of dress by persons of every rank, according as custom, etiquette, caprice, or wealth, may dictate. The principal part of the furs sold in Britain come from our possessions in Canada, or are brought thither to the merchants by the Indians; and in one year there are usually purchased,

106,000	Beaver skins,	6,000	Lynx skins,
2,100	Bear do.	600	Wolverine do.
1,500	Fox do.	1,650	Fisher do.
4,000	Kite fox do.	100	Rackoon do.
4,600	Otter do.	3,800	Wolf do.
17,000	Musquash do.	700	Elk do.
32,000	Marten do.	750	Deer do.
1,800	Mink do.	1,200	Ditto, *dressed*,

500 Buffalo robes, and an immense quantity of castoreum.

All which are received in exchange for goods shipped from this country, as coarse woollen cloths, blankets, arms, ammunition, tobacco, Manchester and Glasgow goods, linens, sheetings, thread, hardware, cutlery and ironmongery, kettles, pots, shoes, hats, hose, spirits, &c.

This will be better illustrated by the following statement:—We will suppose the exchange to be made in the Indian country in 1824-5.

1. The order for the goods was sent to this country, London, for example, ...25th October, 1821.
2. They are shipped from London,..... March, 1822.
3. They arrive in Montreal, ... June, 1822.
4. They are made up in parcels, of 90 lbs. weight each, in the course of that summer and winter, ... 1822.
5. They are sent from Montreal,........ May, 1823.
6. They arrive in the Indian country, and are exchanged for furs in the following winter, ... 1823—1824.
7. Which furs come to Montreal,....... September, 1824.
8. And are shipped for London, where they are sold in March and April, and paid for in May or June,.... 1825.

Thus the merchants lie out of their money three years, from the time they purchase the commodities in England till they receive their returns, and in all four years are consumed before one order, and its consequent sales, are completely closed.

FURLING, the operation of wrapping or rolling a sail close up to the yard, stay, or mast, to which it belongs, and winding a gasket or cord about it, to fasten it thereto. *Furling in a Body*, is a particular method of rolling up a topsail, only practised in harbour, and is performed by gathering all the loose part of the sail into the top about the heel of the top-mast, whereby the yard having as little rolled on it as possible, appears much thinner and lighter than when the sail is furled in the usual manner, which is sometimes termed, for distinction sake, furling in the bunt. *Furling Line*, denotes a cord employed in this operation. *Furling Lines* are generally flat, and are known by the name of gaskets.

FURLONG, a long measure, equal to one-eighth of a mile, or forty poles. It is also used in some law books, for the eighth part of an acre.

FURNACE, is a vessel or building for the purpose of containing combustible and fusible matters, whether of coal, or wood, or metal, and so constructed, that great heat may be produced and concentrated. Furnaces are as various as the purposes to which they are applied; but the requisites of a good furnace are, 1. To be able to concentrate the heat, and direct it as much as possible to the substances to be acted upon. 2. To prevent the dissipation of the heat after it is produced. 3. To obtain the greatest quantity of heat from the smallest quantity of fuel: and 4. To be able to regulate at pleasure the necessary degree of heat, and have it wholly at the artist's management. As far as furnaces were necessarily connected with the word *Chemistry*, we noticed them under that article: we shall in this, though it be in fact but a more extensive application of chemistry, describe some particular furnaces. We premise, however, that under the word Bellows, we have shewn how a continued *blast* may be kept up in any forge or furnace.

Fig. 1.

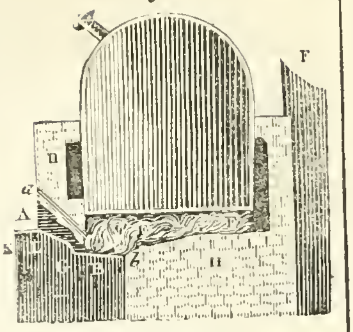
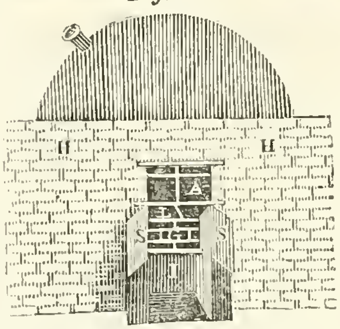


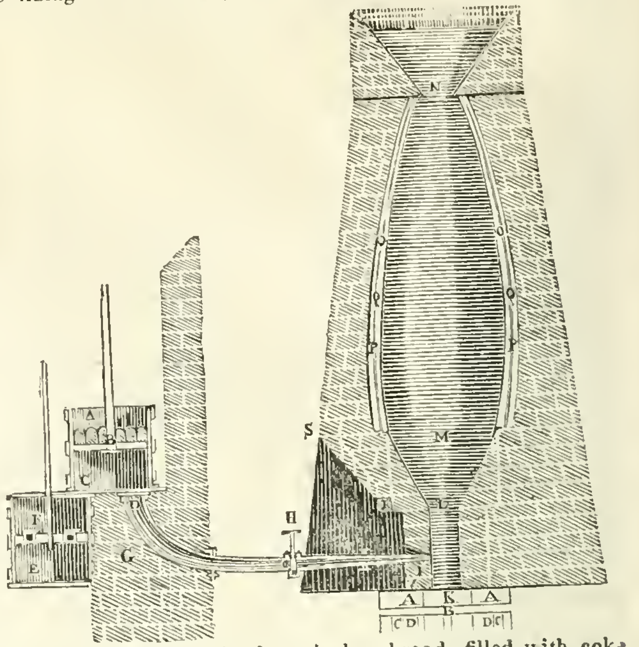
Fig. 2.



Furnace *for Consuming its own Smoke.*—Fig. 1 represents a vertical section, and fig. 2 a front view of a steam boiler, furnished with a *smoke consuming furnace*, and the same letters refer in both to the same parts of the construction.

The opening A, through which the fuel is introduced into the furnace, is shaped somewhat like a hopper, and is made of cast iron, built into the brick work H, H. From the mouth it inclines downward to the place where the fire rests at the bottom of the grate B. The coals in this hopper answer the purpose of a door, and those that are lower are brought into a state of ignition before they are forced into the furnace. A shutter of thin plate-iron is sometimes laid over the hopper, to prevent the entrance of air by that passage. Below the lower plate of the hopper K, *e* the furnace is provided with a grated door G, kept in its position by the catch L, which not only serves to admit air to the fuel, but allows the workmen to push back the fuel from time to time, from *c* to *d*, to make room for fresh quantities to fall into the furnace from the hopper. The refuse of the fuel is cleared out by opening the grated door. The smoke passes from the raw coals over those burning, by the breast *b*, before it can reach the flue F F F. In this way it is burned, and but a small quantity escapes up the chimney. However, by a simple contrivance of a cast-iron plate *a n*, above the fuel, a space is left between it and the hopper, for the admission of fresh air, a thin stream of which rushing down the opening, comes in contact with the smoke given out by the freshest coal, and mixing with it in its passage over the fuel in a high state of combustion, enables it to enflame it so completely, that not a particle of smoke ever escapes undecomposed.

Blast Furnace *for Smelting Iron*, with part of the Blowing Machine. A is the regulating cylinder, 8 feet diameter, and 8 feet high. B, the floating piston, loaded with weights proportionate to the power of the machine. C, the valve by which the air is pressed from the pumping cylinder into the regulator: its length 26 inches, and breadth 11 inches. D, the aperture by which the blast is forced into the furnace. Diameter of this range of pipes, 18 inches; the wider the better, as occasioning less friction, and affording a more powerful column of air. E is the blowing or pumping cylinder, 6 feet diameter, 9 feet high: journey of the piston in this cylinder, from 5 to 7 feet per stroke. F is the blowing piston, and a view of one of the valves, of which there are sometimes two, sometimes four, distributed over the surface of the piston. G, a pile of solid stone building, on which the regulating cylinder rests, and to which the flanch and tilt of the blowing cylinder are attached. H, the safety valve, or cock; by the simple turning of which the blast may be admitted to or shut off from the furnace, and passed off to a collateral tube on the opposite side. I, the tuyere, by which the blast enters the furnace. The end of the tapered pipe, which approaches the tuyere, receives small pipes of various diameters, from 2 to 3 inches, called *nose pipes*, which are applied at pleasure, and as the strength and velocity of the blast may require. K, the bottom of the hearth, 2 feet square. L, the top of the hearth, 2½ feet square. K L, the height of the hearth, 6½ feet. L is also the bottom of the bushes, which terminate of the same size as the top of the hearth, only the former are round and the latter square. M, the top of the bushes, 12 feet diameter, and 8 feet perpendicular. N, the top of the furnace, at which the materials are charged, commonly 3 feet diameter. N N, the internal cavity of the furnace from the top of the bushes, 30 feet high. N R, total height of the internal parts of the furnace, 44½ feet. O O, the lining of fire-bricks, 13 inches long, and 3 inches thick.



P P, a space all round, three inches broad, filled with coke dust, to allow for expansions and contractions of the inner brick lining. Q Q, the second lining, similar to the first. R, a cast-iron lintel, on which the bottom of the arch is supported. R S, the rise of the arch. S T, the height of the arch on the outside, 14 feet, and 18 feet wide. V V, the extremes of the hearth, 10 feet square. This and the bush stones are usually made from a coarse-grained freestone, whose fracture presents large rounded grains of quartz, connected by means of cement less pure.

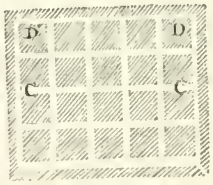


Fig. 2.

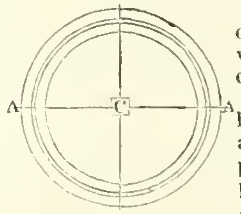


Fig. 3.

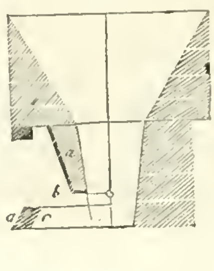


Fig. 1 represents the foundation of the furnace, and a full view of the manner in which the false bottom is constructed. A A, in the upper figure, the bottom stone of the hearth. B, in the same figure, is a stratum of bedding sand. C C, passages by which the vapours, which may be generated from the damps, are passed off. D, D, pillars of brick. The letters in the horizontal view of the same figure, correspond to similar letters in the dotted elevation.

Fig. 2, A A, horizontal section of the diameter of the bushes, the lining and vacancy for stuffing at M. C, is a view of the top of the hearth at L.

Fig. 3. A vertical side section of the bushes and hearth, shewing the tymp and dam stones, and the tymp and dam plates. *a*, the tymp stone. *b*, the tymp plate, which is wedged firmly in the stone, to keep it firm in case of splitting by the great heat. C, the dam stone, which occupies the whole breadth of the bottom of the hearth, excepting about 6 inches, which, when the furnace is at work, is filled every cast with strong sand. This stone is surrounded by an iron plate of considerable thickness, and of a peculiar shape, *d*, and from this called the dam plate. The top of the dam stone and plate is two, three, or four inches under the level of the tuyere hole. The space betwixt the bottom of

the tymp and the dotted line is rammed full of strong sand, and sometimes fine clay. This is called the tymp stopping, and prevents any part of the blast from being unnecessarily expended.

The furnace being finished, the bottom and sides of it, for two feet up the square funnel, receive a lining of common brick upon edge, to prevent the stones from shivering or mouldering, when the fire comes in contact with it. On the front of the furnace is erected a temporary fire-place, about 4 feet long, into the bottom of which are laid corresponding bars. The side walls are made so high as to reach the under surface of the upper tymp stone; excepting a small space, which afterwards receives an iron plate 1½ inch thick, by way of cover. This also prevents the tymp stone from injury by the flame. A fire is now lighted, and fed with small coals, and as the whole cavity of the furnace serves as a chimney for this fire, the draught is consequently violent, and the volume of heat carried up is very considerable. In the course of three weeks, the furnace will be sufficiently dried for the reception of the iron materials. By the introduction of a few baskets of loose fuel and coke, upon the bottom of the furnace, then more, and so on, as it ignites, the furnace is filled, or ⅞ths filled. The furnace before us will contain 900 baskets of coke, each 110 lbs. or 99,000 lbs. of coke in all; and every third day this is renewed, when the furnace is fully worked. The operation of the furnace is kept up by specific quantities of coke, iron-stone, and blast-cinders, being added. The descent of the charge is facilitated by opening the furnace below two or three times a day, throwing out the cold cinders, and admitting for an hour or two a fresh body of air, when the iron-stone begins to fuse, and drop like lava through the iron bars. The filling above is regularly continued till the furnace acquires a good heat above, and then the blast is introduced as follows:

The dam stone is laid in its place, firmly imbedded in fine clay; the dam plate is again imbedded on this with the same cement, and is subject to the same inclination. A channel is made for the scoria, down which it flows in large quantities. The tuyere hole is now opened, and lined with a mixture of fine clay and loam,—the blast is introduced, at first with a small discharging pipe, which is afterwards increased, and in a few hours a quantity of lava will be accumulated. By various minor operations, the metal is finally conducted into moulds, or *sows*, and when detached from these, is termed *pig iron*. In six days after the commencement of blowing, the furnace ought to have worked itself clear.

Iron is a well-known metal, of a livid grayish colour, hard and elastic, and capable of receiving a high polish. Its weight is nearly eight times as great as that of water. It is seldom found in a native state, but occurs abundantly in almost every country of the world in a state of oxyde, and mineralized with sulphuric, carbonic, and other acids. It is found in plants, in several kinds of coloured stones, and even in the blood of animals. After iron ore has been dug out of the earth it is broken into small pieces by machinery, then washed, to detach the grosser particles of earth which adhere to it; then thrown into a furnace, as described above, mixed with a certain portion of limestone and charcoal, for the purpose of being melted. Near the bottom of each furnace there is a tap-hole, through which the liquid metal is discharged into the furrows of a sand bed. The larger mass, or that which flows into the main furrow, is called a *sow*; the smaller ones are denominated *pigs* of iron; and the general name of the metal in this state is *cast iron*.

Cast iron is distinguishable by its properties of being, in general, so hard as to resist both the hammer and the file, being extremely brittle, and for the most part of a dark gray or blackish colour. A great number of useful and important articles are formed of cast iron, such as stoves, grates, chimney backs, pots, boilers, pipes, cannon shot, &c. These are made by casting ladles full of the rough metal into moulds shaped for the purpose, in sifted sand.

Wrought iron. The process of converting cast iron into wrought or malleable iron, is called *blooming*. The cast iron is put into a furnace, and melted by the flame of combustibles, which is made to play upon its surface, a workman constantly stirring it, until, notwithstanding the continuance of the heat, it gradually acquires consistency and congeals. It is then taken out while hot, and violently beaten with a large hammer worked by machinery. *See* FORGE *Hammer*. In this state it is formed into bars for sale. By means of this metal the earth has been cultivated. Without it, houses, cities, and ships could not have been built; and few arts could have been practised. It forms also the machinery by which the most useful and important mechanical powers are generated and applied.

Steel is usually made by a process called *cementation*. This process consists in keeping bars of iron in contact with powdered charcoal, during a state of ignition for several hours in earthen troughs, or crucibles, the mouths of which are closed up with clay. Steel, if heated to redness, and suffered to cool slowly, becomes soft; but if it be plunged whilst hot into cold water, it acquires extreme hardness. And by heating steel to different degrees, it receives different degrees of temper, from that which renders it proper for files, to that which fits it for the manufacture of watch-springs. All kinds of edge tools, where excellence is required, are made of steel; and a steel instrument may be known from an iron one, by letting fall upon it a drop of aqua-fortis; if it be steel, this will occasion a black spot, but if it be iron, it will not have this effect.

FURNITURE, in Dialling, certain additional points and lines drawn on a dial, by way of ornament rather than utility, such as the signs of the zodiac, length of the days, parallels of declination, azimuths, points of the compass, meridians of chief cities, Babylonic, Jewish, or Italian towns.

FUSE, of a Bomb or Grenado, is that which makes the whole powder or composition in the shell take fire. Fuses are chiefly made of dry beech-wood or hornbeam. The composition of fuses is saltpetre 3, sulphur 1 and mealed powder 3, 4, or five parts.

FUSEE, in Clock Work, is that part drawn by the spring, and about which the chain or string is wound.

FUSIBILITY, that quality of metals which renders them liquid; or perhaps, we may define *fusibility* to be the property in metals, which, when a strong heat is applied to them, permits the atoms of which they are composed, to disengage themselves, and become soluble or fluid. Gold is more fusible than iron or copper;—or, the atoms, of which it is composed have a readier affinity to heat than iron or copper, and do thereby separate into an infinity of particles sooner than iron or copper. But silver, tin, and lead, are dissolved sooner than gold, which shews that the atoms of these metals have a greater affinity to the heat applied to them than gold. Borax and some other substances are frequently mixed with metals to render them more fusible, which shews either that the borax augments the heat, or that a particular affinity takes place between the metal and borax, in the affection of both to become liquid, by their attraction or cohesion.

FUSILEERS, in the British service, are soldiers armed like the rest of the infantry, with this difference, that their muskets are shorter and lighter than those of the battalion and the grenadiers.

FUSION, the action of fire, or rather of caloric, on solid bodies, by which they are made to pass into the state of fluidity, and a body rendered liquid by fire is said to be in fusion, that is, to flow or melt. Some bodies cannot be rendered fluid by any heat. These are called infusible, or fire-proof. Several of them may, however, be fused by adding other bodies, which are called fluxes. *See* FLUXES.

FUST, or FAUST, JOHN, a goldsmith of Mentz, and one of the three artists who invented the art of printing. *Guttemberg* invented wooden blocks, which resembled the stereotype plates of the present day. *Schæfer*, the son-in-law of Fust, invented punches and matrices, by means of which this noble art was carried to perfection at once: and Fust supplied money to carry on the business. Fust visited Paris in 1466, to sell a second edition of his Bible, and died of the plague, which carried off 40,000 souls in the months of August and September alone. The monks, whom printing deprived of emoluments arising from the copying of manuscripts, afterwards invented the romance of *Faustus*, the magician, and his selling himself to the devil for 24 years, just as John Tzetzes, the monk, in his Chiliads of the Twelfth Century, palmed upon the world the romantic tale of Belisarius. Now Belisarius did not lose his sight, nor was he ever reduced to beggary, though, from a conspiracy formed against the veteran general, he was accused to Justinian as a rebel: his life was spared, but his fortunes were sequestered, and from June to December he was guarded as a culprit in his own palace. But at length his innocence was acknowledged, his freedom and honours restored, and eight months afterwards he died in his own palace.

FUSTIAN, a cloth made of cotton yarn, both woof and warp, though many cloths of this name are made, of which the warp is flax, or even hemp.

FUSTIC, *Yellow Wood*. This wood, the morus tinctoria, is a native of the West Indies. It affords much colouring matter, which is very permanent. The yellow given by fustic without any mordant is dull, and brownish, but stands well. The mordants which are employed with weld, act on it in a similar manner, and by their means the colour is rendered more bright and fixed. As it abounds more with colouring matter than weld, a less quantity will suffice. The yellow of fustic inclines more to orange than that of weld.

FUTTOCKS, the middle division of a ship's timbers, or those parts which are situated between the floor and the top timbers. Those next the keel are called ground futtocks, and the rest upper futtocks.

FUTTOCK *Shrouds*, or *Foot Hook Shrouds*. The epithet *hook* is frequently applied in common language to any thing bent or incurvated, and particularly to several crooked timbers in a ship, as the breast-hooks, fore-hooks, after-hooks, &c. This term is evidently derived from the lowest part or foot of the timber, and from the shape of the piece.

G.

G, the seventh letter of our Alphabet; as a numeral it was used by the ancients to denote 400, and with a line over it, 40,000. In Music, it is the mark of the treble clef; and from its being placed at the head, or marking the first sound in Guido's scale, the whole scale took the name of Gamut.

GABEL, a word in old records, signifying a tax, rent, custom, or service, paid to the king or lord.

GABIONS, in Fortification, baskets made of osier-twigs, which, being filled with earth, serve as a shelter from the enemy's fire.

GABLE, in Architecture, the upright triangular end of a house, from the eaves to the chimney top.

GAD, among Miners, a punch of iron, with a wooden handle, used to break up the ore.

GAD FLY, or *Breeze* FLY, names given to the black and yellow-bodied œstrus, a fly nearly as large as the common blue flesh fly.

GADOLINITE, a mineral found in Sweden, and called after Gadolin, who first ascertained its composition. The colour, a black or brown. It is brittle, and the specific gravity is 4·0497. With borax it melts into a topaz-yellow glass.

GADUS, the *Cod*, a genus of fishes belonging to the order of jugulares, of which there are seventeen species. The general rendezvous of the cod fish is on the banks of Newfoundland, and the coasts of Cape Breton, Nova Scotia, and New England. The cod grows to a very large size: Mr. Pennant mentions a specimen which weighed 78lbs. and measured 5ft. 8in. in length, and 5ft. in girth round the shoulders; but the general weight is from 14 to 40lbs.

The food of the cod is small fish, worms, testaceous or crustaceous animals, such as crabs, &c. and its digestion is so powerful as to dissolve the greatest part of the shells it swallows. The fishermen are well acquainted with the use of the air bladder or sound of this fish, and dexterously perforate the living fish with a needle to let out the air contained. The sounds, when salted, are reckoned a delicacy. A species of isinglass is also prepared from this part of the fish by the natives of Iceland. The haddock, whiting, dorse, coal fish, ling, and turbot, are species of the cod.

GAFF, a sort of boom, used in small ships, to extend the upper edge of the mizzen, and employed for the same purpose on those sails whose foremost edges are joined to the masts by hoops or lacings, and which are usually extended by a boom below; such are the main-sails of sloops, brigs, and schooners. The foremost end of the gaff is furnished with two cheeks forming a semicircle, which enclose the after part of the mast, and is secured in this position by a rope passing from one of the cheeks to the other on the fore side of the mast, on which are strung several small wooden balls, called trucks, to lessen the friction of the rope on the mast when the sail is hoisting or lowering. It is further secured in this situation by a rope passing from one of the cheeks to the other on the fore side of the mast, and to prevent the friction of this rope upon the mast, by hoisting or lowering, several little wooden balls, called trucks, are hung upon it, in the same manner as beads are hung upon the Indians' strings of wampum.

GAGE, is a term employed to denote various instruments used for measuring the state of rarefaction in the air-pump, variations in the barometer, &c. The Gage of the *Air Pump* is of a variety of forms, as, the *Barometer Gage*, the *Syphon Gage*, the *Pear Gage*, &c.

Short Barometer GAGE is merely the lower part of a barometer, or a tube about eight or nine inches in length, filled with mercury, and immersed with its aperture into a small quantity of the same fluid, contained in a glass vessel which forms the cistern. This gage is either placed under the receiver upon the principal plate of the pump, or it is placed under a separate small receiver on an auxiliary plate attached to some pumps for this purpose. As this gage is not equal to a whole barometer, it will not begin to shew the state of rarefaction till after three-fourths of the air have been exhausted, that is, when the elasticity of the remaining air is about one-fourth of that of common air, the barometer itself being but about one-fourth of the usual height of the mercury; but after this, the farther decrease of elasticity is exhibited by the sinking of the mercury, and a graduated scale attached to the instrument.

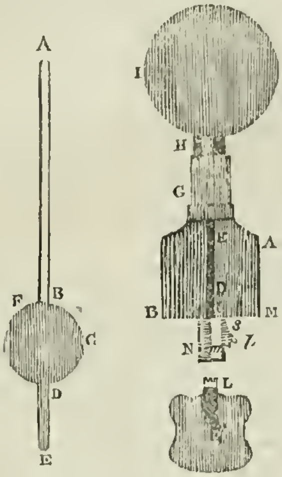
There is another gage, called the *Long Barometer* GAGE, which works in a similar manner, and indicates the state of rarefaction on nearly the same principles.

Syphon GAGE. This differs from the short barometer gage, only in this; that instead of terminating in a small cistern, in this gage the tube is bent, and rises upwards with its aperture, which by means of a brass tube is made to communicate with the inside of the pump, so that the ascending leg of the tube performs the office of a cistern.

Pear GAGE. This is the invention of Mr. Smeaton, and is thus denominated from its form, which resembles that of a pear. This gage does not indicate the rate of rarefaction as it proceeds, but shews the ultimate state to which it was carried after the re-admission of the air. The gage is suspended in the receiver, and exhausted to the same degree; but when this is carried on as far as is intended, the open orifice of the gage is let down into a vessel of mercury, which, upon the re-admission of the air, is forced into the pear, and thus the ultimate state of rarefaction is determined.

GAGE of the *Barometer*, is a contrivance for estimating the exact degree of the rise or fall of the mercury in the barometrical tube. It is obvious, that when the mercury sinks in the tube it rises in the cistern, and *vice versa*; and as the distance between the divisions graduated on the annexed scale, and the surface of the mercury in the cistern, is not truly shewn by the numbers on the scale, errors must happen in determining the exact height of the mercury. To remedy this inconvenience, a line is cut upon a round piece of ivory, which is fixed near the cistern; this line is accurately placed at a given distance from the scale, as for instance, twenty-seven inches; and a small float of cork, with a cylindric piece of ivory fixed to its upper surface, (on which a line must be cut at a distance of two inches, exactly from the under surface of the cork,) is left to play freely on the quicksilver, and the cylinder works in a groove made in the other piece; from this construction it appears, that if these marks are made to coincide, by raising or lowering the screw which acts on the quicksilver, then the divisions on the scale will express the true measure of the distance from the surface.

Gage of the *Condenser*, is a glass tube of a particular construction, adapted to the condensing engine, and designed to shew the exact density and quantity of the air contained at any time in the condenser.



Sea Gage, is an instrument invented by Dr. Hales and Dr. Desaguliers, for finding the depth of the sea, the description of which is this. A B, in the annexed figure, is the gage-bottle, in which is cemented the gage-tube E *f*, in the brass cap at G. The upper end of the tube E, is hermetically sealed, and the open lower end *f*, is immersed in mercury, marked C, on which swims a small quantity of treacle. On the top of the bottle is screwed a tube of brass H G, pierced with several holes, to admit the water into the bottle A B. The body K, is a weight hanging by its shank L, in a socket N, with a notch on one side at *m*, in which is fixed the catch *l* of the spring *s*, and passing through the hole L, in the shank of the weight K, prevents its falling out when once hung on. On the top, in the upper part of the brass tube at H, is fixed a large empty ball, or full-blown bladder I, which must not be so large, but that the weight K may be able to sink the whole under water. The instrument thus constructed, is used in the following manner:—The weight K being hung on, the gage is let fall into deep water, and sinks to the bottom; the socket N is somewhat longer than the shank L, and therefore, after the weight K comes to the bottom, the gage will continue to descend, till the lower part of the socket strikes against the weight; this gives liberty to the catch to fly off the hole, whereby the weight K is disengaged; when this is done, the ball or bladder, I, instantly buoys up the gage to the top of the water. While the gage is below, the water, having free access to the treacle and mercury in the bottle, will by its pressure force it up into the tube; and E *f*, the height to which it has been forced by the greatest pressure, *viz.* that at the bottom, will be shewn by the mark in the tube which the treacle leaves behind it, and which is its only use. This shews into what space the whole air in the tube E *f* is compressed, and consequently the height or depth of the water, which by its weight produced that compression, which is the thing required.

If the gage tube E *f* were of glass, a scale might be drawn on it with the point of a diamond, shewing by inspection what height the water stands above the bottom. But the length of 10 inches is not sufficient for fathoming depths at sea, because, when all the air in such a length of tube is compressed into half an inch, the depth of water is not more than 634 feet, which is not half-a-quarter of a mile.

If to remedy this, we make use of a tube 50 inches long, which for strength may be a musket-barrel, and suppose the air compressed into an hundredth part of an inch; then by saying, as 1 : 99 :: 400 : 39600 inches, or 3300 feet; even this is but little more than half a mile, or 2640. But since it is reasonable to suppose the cavities of the sea bear some proportion to the mountainous parts of the land, some of which are more than three miles above the earth's surface; therefore, to explore such great depths, Dr. Hale contrived a new form for his sea gage, or rather for the gage-tube in it, which is as follows:—B C D F, is a hollow metallic globe, communicating on the top with a long tube A B, whose capacity is a ninth part of that globe. On the lower part at D, it has also a short tube D E, to stand in the mercury and treacle. The air contained in the compound gage-tube is compressed by the water as before; but the degree of compression, or height to which the treacle has been forced, cannot here be seen through the tube; therefore, to answer that end, a slender rod of metal or wood, with a knob on the top of the tube A B, will receive the mark of the treacle, and shew it when taken out.

If the tube A B be 50 inches long, and of such a bore that every inch in length shall be a cubic inch of air, and the contents of the globe and tube together 500 cubic inches; then, when the air is compressed within an hundredth part of the whole, it is evident the treacle will not approach nearer than five inches of the top of the tube, which will agree to the depth of 3300 feet of water as above. Twice this depth will compress the air into nearly half that space, *viz.* 2½ inches, corresponding to 6600, which is a mile and a quarter. Again, half that space, or 1¼ inch, will shew double the former depth, *viz.* 13,200 feet, or 2½ miles, which is probably very nearly the greatest depth of the sea.

Bucket Sea Gage, is an instrument contrived by Dr. Hales to find the different degrees of coolness and saltness of the sea, at different depths, consisting of a common household pail or bucket with two heads to it. These heads have each a round hole in the middle, near four inches diameter, and covered with valves opening upwards, and that they may both open and shut together, there is a small iron rod fixed to the upper part of the lower valve, and at the other end to the under part of the upper valve; so that as the bucket descends with its sinking weight into the sea, both the valves open by the force of the water, which by that means has a free passage through the bucket. But when the bucket is drawn up, then both the valves shut by the force of the water at the upper part of the bucket; whereby it is brought up full of the lowest sea-water to which it has descended.

When the bucket is drawn up, the mercurial thermometer, fixed in it, is examined; but great care must be taken to observe the degree at which the mercury stands, before the lower part of the thermometer is taken out of the water, in the bucket, as it would otherwise be altered by the different temperature of the air. In order to keep the bucket in a right position, there are four cords fixed to it, reaching about four feet below it, to which the sinking weight is attached.

Tide Gage. This is an instrument used for determining the height of the tides, by Mr. Bayley, in the course of a voyage towards the south pole, &c. in the Resolution and Adventure, in the years 1772, 1773, 1774, 1775. This instrument consists of a glass tube, whose internal diameter was seven-tenths of an inch, lashed fast to a ten-foot fir rod, divided into feet, inches, and parts; the rod being fastened to a strong post fixed firm and upright in the water. At the lower end of the tube was an exceedingly small aperture, through which the water was admitted. In consequence of this construction, the surface of the water in the tube was so little affected by the agitation of the sea, that its height was not altered the tenth-part of an inch, when the swell of the sea was two feet, and Mr. Bayley was certain, that with this instrument he could discern a difference of the tenth of an inch in the height of the tide.

Wind Gage, is an instrument for measuring the force of the wind upon any given surface. *See* Anemometer.

Gage, among Letter Founders, a piece of box, or other hard wood, variously notched; the use of which is to adjust the dimensions, slopes, &c. of the different sorts of letters. There are several kinds of these, as the flat-gage, the face-gage, the italic-gage, &c.

Gage, *Sliding*, a tool used by Mathematical Instrument-makers, for measuring and setting off distances. It is also of use in letter cutting, and making of moulds.

GALANTHUS, the *Snow Drop*, a genus of the monogynia order, in the hexandria class of plants, and in the natural method ranking under the ninth order, spathaceæ.

GALAXY, Via Lactea, or *Milky Way*, in Astronomy, that long, luminous track or zone, which encompasses the heavens, forming nearly a great circle of the celestial sphere. It is inclined to the plane of the ecliptic at about an angle of 60°, and cuts it nearly at the two solstitial points. It traverses the constellations Cassiopeia, Perseus, Auriga, Orion, Gemini, Canis Major, and the Ship, where it appears most brilliant in southern latitudes; it then passes through the feet of the Centaur, the Cross, the southern Triangle, and returns towards the north by the Alter, the tail of the Scorpion, and the arc of Sagittarius, where it divides into two branches, passing through Aquila, Sagitta, the Swan, Serpentarius, the head of Cepheus, and returns into Cassiopeia.

Milton also speaks of it in the following beautiful, and appropriate language:—

> " A broad and ample road, whose dust is gold,
> And pavement stars, as stars to thee appear,
> Seen in the Galaxy, that milky way,
> Which nightly, as a circling zone thou seest,
> Powdered with stars."

The ancients had many singular ideas as to the cause of this phenomenon; but modern astronomers have long attributed it to a great assemblage of stars, and Dr. Herschel has confirmed these conjectures, having discovered, in a space of about 15° long, by 2° broad, no less than 50,000 stars. This, however, instead of satisfying the curiosity of astronomers, only gave rise to farther inquiries and hypotheses; amongst others, that of Dr. Herschel's, which is very interesting; he supposes the sidereal universe to be distributed into nebulæ and clusters of stars, and the milky way to be that particular cluster in which our sun is placed. In a paper on the construction of the heavens, Dr. Herschel says, it is very probable, that the great stratum called the milky way, is that in which the sun is placed, though perhaps not the centre of its thickness, but not far from the place where some smaller stratum branches from it. Such a supposition will satisfactorily, and with great simplicity, account for all the phenomena of the milky way, which, according to this hypothesis, is no other than the appearance of the projection of the stars contained in this stratum, and its secondary branch.

In another paper on the same subject, he says, " We will now retreat to our own retired station in one of the planets attending a star in the great combination with numberless others; and in order to investigate what will be the appearances from this contracted situation, let us begin with the naked eye. The stars of the first magnitude, being in all probability the nearest, will furnish us with a step to begin our scale; setting off, therefore, with the distance of Sirius or Arcturus, for instance, as unity, we will at present suppose, that those of the second magnitude are at double, and those of the third at treble the distance, and so forth. Taking it then for granted, that a star of the seventh magnitude is about seven times as far from us as one of the first, it follows that an observer, who is enclosed in a globular cluster of stars, and not far from the centre, will never be able, with the naked eye, to see the end of it: for since, according to the above estimations, he can only extend his view about seven times the distance of Sirius, it cannot be expected that his eyes should reach the borders of a cluster, which has, perhaps, not less than fifty stars in depth every where around him. The whole universe, therefore, to him, will be comprised in a set of constellations, richly ornamented with scattered stars of all sizes. Or if the united brightness of a neighbouring cluster of stars should, in a remarkably clear night, reach his sight, it will put on the appearance of a small, faint, nebulous cloud, not to be perceived without the greatest attention. Allowing him the use of a common telescope, he begins to suspect that all the milkiness of the bright path which surrounds the sphere may be owing to stars. By increasing his power of vision, he becomes certain that the milky way is, indeed, no other than a collection of very small stars, and the nebulæ nothing but clusters of stars."

Dr. Herschel then solves a general problem for computing the length of the visual ray; that of the telescope which he uses will reach to stars 497 times the distance of Sirius. Now Sirius cannot be nearer than 100,000 × 190,000,000 miles, therefore Dr. Herschel's telescope will at least reach to 100,000 × 190,000,000 × 497 miles. And Dr. Herschel says, that in the most crowded part of the milky way, he has had fields of view that contained no less than 588 stars, and these were continued for many minutes, so that in a quarter of an hour he has seen 116,000 stars pass through the field of view of a telescope of only 15′ aperture: and at another time, in 41 minutes, he saw 258,000 stars pass through the field of his telescope. Every improvement in his telescope has discovered stars not seen before, so that there appears no bounds to their number, or to the extent of the universe.

GALBANUM, a gum issuing from the stem of an umbelliferous plant, growing in Persia, and many parts of Africa.

GALE, Electrical. On the 6th December, 1823, about 100 miles west of Drontheim, a gale of wind lasted three days without intermission, and afforded the following proofs of its having originated in a disturbed state of electricity in the atmosphere. It was accompanied by frequent and vivid lightning, unusual in high latitudes in winter; and at the mastheads and yard-arms of the Griper, commanded by Captain Clavering, not fewer than eight balls of fire were visible at once.

GALENA, in Mineralogy, the sulphuret of lead, found both in masses and crystallized. The primitive form of its crystals is a cube. Its colour is bluish gray like lead, but brighter. Lustre metallic. Texture foliated. Fragments cubical. Soft but brittle. Specific gravity 7·22 to 7·587. Effervesces with nitric and muriatic acids. It is composed of from 45 to 83 lead, and from 0·86 to ·16 of sulphur. It generally contains some silver, and sometimes also antimony and zinc.

GALENIC, or Galenical, in Pharmacy, a manner of treating diseases, founded on the principles of Galen, in opposition to the chemical practitioners.

GALEOPITHECUS, Colugo. A genus of quadrupeds, natives of the Molucca and Philippine islands, frequenting woody places, and feeding principally on fruits. The Colugo resides on trees, and in descending from the top of a tree, it spreads its membranes, and balances itself to the place it aims at in a gentle manner; but in ascending, it uses a leaping pace. The whole length of the animal is about three feet; the breadth, when expanded, nearly the same; the tail is slender, and about a span long. The membrane, or expansile skin, by which it is enabled to fly, is continued on each side, from the neck to the fore feet, thence to the hind feet, and again to the tail: it is covered with fur, in the same manner as the body. The whole upper side of the animal is generally of a deep ash colour, and the whole under side, both of the body and membrane, is yellow. The head is long. The ears are small, round, and marked internally by numerous semicircular transverse streaks. The legs are clothed with a yellow down: there are five toes on each foot, united by a membrane, and terminating in crooked claws. This animal is called by the Indians caguang, colugo, and gigua. It was first described by Bontius, in the history of Java.

GALILEO, Galilei, a very celebrated mathematician and astronomer, was the son of a Florentine nobleman, and born in the year 1564. He had from his infancy a strong inclination to philosophy and the mathematics, and made prodigious progress in these sciences. In 1592 he was chosen professor of mathematics at Padua, and during his abode there he is said to have invented the telescope; or, according to others, improved that instrument, so as to render it fit for astronomical observations. In 1611, Cosmo II. Grand Duke of Tuscany, sent for him to Pisa, where he made him professor of mathematics, with a handsome salary; and soon after, inviting him to Florence, gave him the office and title of principal philosopher and mathematician to his highness. In 1612 he discovered some spots on the sun's disc, which led to the publication of a pamphlet asserting the truth of the Copernican system of astronomy. For this he was cited before the inquisition at Rome; and after some months' imprisonment, released, on a simple promise that he would renounce his heretical opinions. In 1632 he published his dialogues on the Ptolemaic and Copernican systems of the world, for which he was again cited before the Inquisition, imprisoned, his book burned, and condemned to repeat once a week, for three years to come, seven penitential psalms, as a saving penance for his heresies. He lived ten years after this, and died in 1642, in the 78th year of his age. For the purpose of astronomical observations, he improved the telescope, first invented by Jansen, and was himself the contriver of the simple pendulum; and thought of applying it to clocks, but did not execute that design. He, together with his pupil Torricelli, discovered that air had gravity, and endeavoured to compare it with water. As a great promoter of the sciences, he opened vast fields for the inquiries of others, and ably assisted them by his inventions and discoveries.

Galileo wrote a number of treatises, many of which were published in his lifetime. Many of his pieces were, however, lost at his death, as some say, through the superstition of one of his nephews, or, as others say, through the artifice of his wife's confessor; at all events, they were destroyed, in consequence of their being supposed to contain doctrines which the Inquisition declared to be heretical.

GALL, in the animal economy, the same with bile.

GALL *Bladder*, called Vesicula, and Cystis Fellia, is usually of the shape of a pear, or the size of a small hen's egg. It is situated on the concave side of the liver, and lies upon the colon, part of which it tinges with its own colour. It is composed of four membranes, or coats; the common, the vesicular, the muscular, and the nervous one, which last is of a wrinkled or reticulated surface within, and furnished with an unctuous liquor. The use of the gall-bladder is to collect the bile, secreted in the liver, and mixing with its own peculiar produce, to perfect it farther, to retain it a certain time, and then to expel it.

GALL, in Natural History, denotes any protuberance or tumour produced by the puncture of insects on plants and trees of different kinds. Galls are of various forms and sizes, and no less different with regard to their internal structure. Some have only one cavity, and others a number of small cells communicating with each other. Some are as hard as the wood of the tree they grow on, others are soft and spongy; the first are termed gall nuts; and the latter berry galls, or apple galls. Oak-galls, put into a solution of vitriol in water, give it a purple colour, which, as it grows stronger, becomes black, and on this property depends the art of making our writing ink and dyes.

GALL *Stones*, calculous concretions frequently formed in the gall bladder, and sometimes occasioning great pain in their passage through the ducts into the duodenum, before they are evacuated. Gall-stones often occur in the inferior animals, particularly in cows and hogs; but the biliary concretions of these animals have not hitherto been examined with much attention. Soaps have been proposed as solvents for these calculi. The academy of Dijon has published the success of a mixture of essence of turpentine and ether.

GALLATES, salts formed by the gallic acid with alkaline earths or metallic bases.

GALLERY, a balcony, projecting from the stern or quarter of a ship of war, or of a large merchantman.

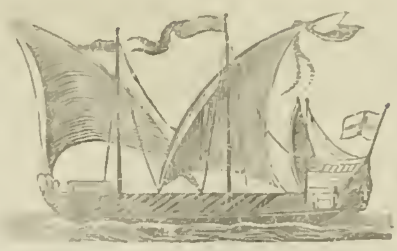
Stern **GALLERY**, that part of the preceding article which is wholly at the stern of the ship, and is usually decorated with a balustrade extending from one side of the ship to the other; the forepart is limited by a partition, called the *skreen bulkhead*, in which are framed the cabin windows, and the roof of it is formed by a sort of vault, termed the *cove*, which is frequently ornamented with sculpture.

Quarter **GALLERY**, is that part which projects on each quarter, and is generally fitted up as a water closet. Ships of twenty guns and upwards, on one deck, have quarter galleries, but no stern gallery; two and three deckers have two or three of these conveniences on each side, one under the other, and one or two stern galleries.

GALLERY, in Architecture, a covered place in a house, usually in the wings of a building, its use being chiefly to walk in.

GALLERY, in Fortification, a covered walk across the ditch of a town; and as a *mine*, it is a narrow passage from one part of the mine to another.

GALLEY, a kind of low flat-built vessel, furnished with one deck, and navigated with sails and oars, particularly in the Medictrranean. The largest sort of these vessels, called galleasses, were formerly employed by the Venetians; they were about 162 feet long above, and 133 feet by the keel, 32 feet wide, and 23 feet length of sternpost. They were furnished with three masts, and 32 banks of oars, each bank containing two oars, and every oar being managed by six or seven slaves, who were usually chained thereto. In the forepart they had three small batteries of cannon, *viz.* two 36-pounders, two 24-pounders, and two 2-pounders; they had also three 18-pounders on each quarter, and carried from 1000 to 1200 men.



The galleys next in size to these are called half-galleys, and are from 120 to 130 feet long, 18 feet broad, and 9 or 10 feet deep. They have two masts, which may be struck at pleasure, and are furnished with two large lateen sails, and five pieces of cannon. They have commonly twenty-five banks of oars, as described above. A size still less than these are called quarter galleys, carrying from 12 to 16 banks of oars. They generally keep close under the shore, but sometimes venture out to sea to perform a summer cruise.

In France are forty galleys for the use of the Mediterranean, the arsenal thereof being at Marseilles. The general of the galley bears a double anchor, placed *in pale* behind the escutcheon of his arms, as a mark of his office. The captain galley is the principal galley of a state, commanded by the captain-general of the galleys. In France, before the Revolution, the royal galley was the first. These galleys in France resemble the hulks of Britain, in which the convicts labour, and are confined.

GALLEY, is also a name given to an open boat, rowing six or eight oars, and used on the river Thames by custom-house officers, press-gangs, and also for pleasure; hence the appellation of custom-house galley, press-galley, &c.

GALLEY, or *Gally*, is also the name of the kitchen of a ship of war, or the place where the grates are put up, fires lighted, and the victuals generally boiled or roasted. In East India ships it is generally termed the cook-room, and on board of merchantmen it is called the caboose.

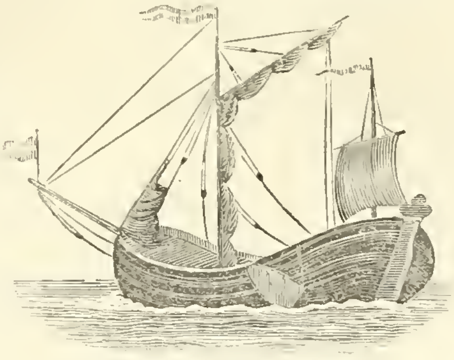
GALLEY *Slave*, a person condemned to work at the oar on board a galley, being chained to the deck. Condemnation to the galleys is a punishment peculiar to France, whereby criminals and delinquents are adjudged to serve as slaves on board the galleys, either during life, or for a limited time. A man condemned for perpetuity is dead in a civil sense; he cannot dispose of any of his effects; cannot inherit; and if he be married, his marriage is null, nor can his widow have any of her dower out of his goods, which, with his lands, are hereby confiscated.

GALLIC ACID, in Chemistry, is obtained from the oak nut-gall. In an infusion of galls made with cold water, a sediment is formed which has a crystalline form and an acid taste. By an infusion of galls exposed to the air, and removing now and then the mouldy skin formed on its surface, a large quantity of this sediment was obtained; which being edulcorated with cold water, redissolved in hot water, filtrated and evaporated very slowly, yielding an acid salt in crystals as fine as sand. Or, boil a mixture of carbonate of barytes and an infusion of nut-galls. A bluish green liquid is obtained, which consists of a solution of gallic acid and barytes. Filter and saturate with diluted sulphuric acid. Sulphat of barytes is deposited in the state of an insoluble powder, and a colourless solution of gallic acid remains. Gallic acid when pure, is in the form of transparent plates. Its taste is acid, and somewhat astringent; and when heated it has a peculiar and rather unpleasant aromatic odour.

GALLINÆ, in Ornithology, the fifth order of birds. Under which are comprehended the peacock, pheasant, turkey, the common cock, partridge, grouse, dodo, &c.

GALLING Fire, a repeated discharge of cannon, or small arms, which, by its execution, greatly annoys the enemy.

GALLIOT, a Dutch vessel, carrying a main and a mizzen mast, and a large gaff-main-sail.



A galliot is a sort of a brigantine, or small galley, built very slightly, and designed only for chase. She can both sail & row, and usually carries about two or three pedreros, and has sixteen or twenty oars. All the seamen on board are soldiers, and each has a musket by him on quitting his oar. Some also call the bomb-ketches galliots.

GALLON, an English measure of capacity, being equal to 4 quarts or 8 pints.

	Cub. Inches.
The gallon, wine measure, contains..........	231
Ditto, beer measure,....................	282
Ditto, dry measure,.....................	268¼

GALLOON, in Commerce, a narrow kind of lace used to edge or border cloths.

GALLOWS Bits, a frame of timber, in form of a gallows, forming a support for the spare topmasts, yards, and booms.

GALVANI, Lewis, a modern philosopher, who has had the honour of giving his name to a newly discovered principle in nature, was born at Bologna, in 1737, where he practised medicine, was public lecturer at the university, and reader in anatomy in the Institute of the same city. His reputation, as an anatomist and physiologist, was established in the schools of Italy, when accident gave birth to the discovery which has immortalized his name. His wife, with whom he lived many years in the tenderest union, was at this time in a declining state of health. As a restorative, she made use of a soup of frogs; and some of these animals, skinned for the purpose, happened to lie upon a table in her husband's laboratory, upon which was placed an electrical machine. One of the assistants, in his experiments, happened accidentally to bring the point of a scalpel near the crural nerves of a frog, lying not far from the conductor. Instantly the muscles of the limb were agitated with strong convulsions. Madame Galvani, a woman of quick understanding, and of a scientific turn, was present, and, struck with the phenomenon, she immediately went to inform her husband of it. He came, and repeated the experiment; and soon found that the convulsion only took place when a spark was elicited by the conductor. It was Volta, however, who brought to a system the crude and erroneous opinions of Galvani, who would have within all animals a peculiar electrical fluid, secreted by the brain, and diffused by the nerves through various parts of the body. However, from this simple experiment, or rather accident, arose the new science of Galvanism, which has made, and is still making, such a rapid progress in the hands of modern chemists and philosophers. Galvani died in 1798, in the 61st year of his age.

GALVANISM, a modern and very interesting branch of science, thus named after its celebrated discoverer, professor Galvani, of Bologna. (See the preceding article.) Galvanism comprises all those electrical phenomena arising from the chemical agency of certain metals with different fluids.

We have noticed, in the foregoing article, the humble origin of this science; and that by accident it was discovered, that common electricity had the property of producing muscular contractions in the limbs of animals even a considerable time after death; and of this Galvani more clearly convinced himself, by ascertaining, that from whatever source the electricity was drawn, the effect of it was still the same. But in one instance he found, that the mere agency of a metallic substance, where he had no reason to suspect the presence of electricity, the limbs of a recently killed frog were convulsed; and after making several experiments, he ascertained, that the convulsions only took place when he employed dissimilar metals.

Galvani's experiments were repeated by many eminent philosophers, both on the continent and in this country. None of them, however, added any thing new to what Galvani had himself discovered, excepting the celebrated Volta, whose improvement was so decided, that the science itself has nearly changed its name, taking that of Voltaism instead of Galvanism.

When we view, indeed, the numerous facts that have been added to the labours of Galvani, his discoveries form but a very small part of the whole mass, whereas a great many of them are due to Volta. Yet when we recollect again, that the investigation began with the former, and was in a great degree promoted by his own perseverance, we must ever consider him as a principal in this extensive field of research; and cannot, without injustice, deprive him of the honour which has been conferred upon him, of giving his own name to the science which he discovered and promoted. Philosophy, however, is infinitely indebted to Signior Volta, it being to him that we owe, in a great measure, the rapid progress that has since been made in this interesting branch of philosophy. He repeated the experiments of Galvani, and found, that when two pieces of metal of different kinds were placed in different parts of an animal at the same time, that the metals were brought in contact, or were connected by a metallic arc; as often as the contact was made, convulsions were observed. He found that the greatest was produced when the metals were zinc and silver. When several pairs of metals were employed, having pieces of moist cloth between them, the effect appeared to increase as the number of pairs. This important discovery of accumulating the effects of this species of electricity, was made by Volta in 1800, and hence has been denominated the *Voltaic pile*. The apparatus first made by Volta, consisted of a certain number of pairs of zinc and silver plates, separated from each other by pieces of wet cloth; the arrangement being as follows: zinc, silver, wet cloth; zinc, silver, wet cloth, and so on. The silver plates were chiefly silver coins, the plates of zinc and the pieces of cloth being of the same size. He found this pile much more powerful when the pieces of cloth were moistened with a solution of common salt instead of pure water, and an apparatus consisting of forty pairs of plates, he found to possess the power of giving a very smart shock, similar to that of a small electric jar; and that this effect took place as often as a communication was made between each end of the pile, and as long as the pieces of cloth remained moist.

An account of this discovery was communicated to the Royal Society, and published in the Philosophical Transactions. Since this time we have no account of any farther discoveries of Volta; but the science of Galvanism has been since considerably extended by the researches and experiments of philosophers in France, England, and other countries.

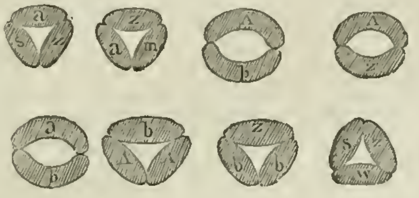
The first experiments made on the pile in this country were performed by Messrs. Nicholson and Carlisle, who observed, that on bringing the wires from each end of the column in contact with a drop of water, bubbles of some elastic gas were disengaged, which, on closer examination, they found to be hydrogen gas; this discovery gave rise to a great variety of experiments, and to many interesting results, but being chiefly chemical, we cannot here enter into their details.

The Galvanic energy evinced in the decomposition of bodies, which the experiments of Nicholson and Carlisle had first made known, was farther prosecuted by Mr. Cruikshank, of Woolwich, to whom we are indebted for the invention of the Galvanic trough, which we have described under the article *Galvanic* Battery. This again led the way to other batteries of similar construction, but of a more powerful nature, by which it was found, that all the metals reduced into thin leaves were deflagrated with brilliant, though differently coloured flames; and henceforth Galvanism, which had not before assumed any particular character, it being doubtful to what branch of science it properly belonged, was directed entirely to chemistry, and has since been the means of throwing great light on that interesting branch of human knowledge.

The Laws of Galvanic Combination.—The conductors of electricity are divided into two principal classes. The first class, called dry and perfect conductors, are metallic substances and charcoal. Those of the second class, or the imperfect conductors, are water and other oxidating fluids. But as the substances of the second class differ in conducting power much more than those of the first class, so they may be subdivided into species.

Imperfect Conductors.—It may be observed, that water holding in solution common air, and especially oxygen gas, is much more active than water deprived of air by boiling. 2. Water mixed with clay or chalk; 3d, a solution of sugar; 4th, alcohol; 5th, milk; 6th, mucilaginous fluids; 7th, animal gelatinous fluids; 8th, wine; 9th, vinegar, and other vegetable juices, and acids; 10th, saliva; 11th, mucus from the nose; 12th, blood; 13th, brains; 14th, solution of salt; 15th, soap-suds; 16th, chalk water; 17th, concentrated mineral acids; 18th, strong alkaline leys; 19th, alkaline fluids; 20th, sulphuret of potash.

Simple Combinations of Galvanic Conductors, capable of producing effects, must consist of three different conductors, for two produce no effect. One conductor must be of one class, and the two other conductors different of the other class. Denoting the bodies of the first class by means of three capital letters, and those of the second class by small letters, the combinations of No. 1 and 2 are *active*, but those of 3, 4, 5, are not activo; because they consist of two bodies only, and those of figs. 7 and 8 consist of three bodies; of which two are of the same sort, and of course act as a single body.



When two of the three bodies are of the first class, and one of the second, the combination is said to be of the first order; otherwise, it is said to be of the second order. In a single active galvanic combination, or, as it is commonly called, a simple galvanic circle, the two bodies of one class must touch each other in more than one point, at the same time that they are connected together at other points by the body of the other class. Thus, when a prepared frog is convulsed by the contact of the same piece of metal in two different places, then the fluids of those parts, which must be somewhat different from each other, are the two conductors of the second class, and the metal is the third body on the conductor of the first class. If two metals are used, then the fluids of the prepared animals differing but little from each other, may be considered as one body of the second class. Thus also, when a person drinks out of a pewter jug, the saliva or moisture of his under lip is one fluid or one conductor of the second class, the liquor in the jug is the other, and the metal is the third body, or conductor of the first class.

It seems to be indispensably requisite, that in a simple galvanic circle, the conductor or conductors of one class should have some chemical action upon the other conductor or conductors; without which circumstance the combination of the three bodies will have either no galvanic action at all, or a very slight one. Farther, the galvanic action seems to be proportionate to the degree of chemical agency; which seems to shew, that such chemical action is the primary cause of the electric phenomena. The most active galvanic circles of the first order, are, when two solids of different degrees of oxidability are combined with a fluid, capable of oxidating at least one of the solids. Thus, gold, silver, and water, do not form an active galvanic circle; but the circle will become active if a little nitric acid, or any fluid decomposable by silver, is mixed with the water.

A combination of zinc, silver, and water, forms an active galvanic circle, and the water is found to oxidate the zinc, provided the water holds in solution some atmospherical air, as it commonly does, and especially if it contains oxygen gas. But zinc, silver, and water, containing a little nitric acid, form a more powerful galvanic circle, the fluid being capable of acting both upon the zinc and upon the silver. The most powerful galvanic combinations of the second order are, when two conductors have different chemical actions on the conductors of the first class, at the same time that they have an action upon each other. Thus, copper, silver, or gold, with a solution of alkaline sulphuret, and diluted nitrous acid, form a very active galvanic circle. The present state of knowledge relative to this subject, does not enable us accurately to determine the particular powers of all sorts of galvanic combinations: the following lists, however, contain an useful arrangement of the best combinations, disposed in the order of their powers, and commencing with the most powerful.

Table of Galvanic Circles of the First Order.—These circles consist of two conductors of the first class, and one of the second. 1. Zinc, with gold, charcoal, silver, or copper, tin, iron, or mercury, and water containing a small quantity of any of the mineral acids. 2. Iron, with gold, charcoal, silver, copper, or tin, and a weak solution of any of the mineral acids. 3. Tin, with gold, silver, or charcoal, and a weak solution of any of the mineral acids. 4. Lead, with gold or silver, and a weak acid solution. 5. Any of the foregoing metallic combinations, and common water. 6. Copper, gold, silver, and a solution of nitrate of silver and mercury, or nitric or acetous acid.

Galvanic Circles of the Second Order, consist of one conductor of the first class, and two of the second. Charcoal, copper, silver, lead, tin, iron, or zinc, with water, or a solution of any hydrogenated alkaline sulphurets, capable of acting on the first three metals only, and a solution of nitrous acid, or oxygenated muriatic acid, capable of acting upon metals.

Theory of the Action of Galvanic Circles.—The action of a single galvanic circle depends on the quantity of surface in contact between the acting bodies; and a high temperature is favourable to this activity. If a circle consist of gold, zinc, and water, the interposition of iron or silver, or both, does not alter the activity. Hence it appears that the action of a galvanic circle may be conveyed through extraneous conductors to a considerable distance; but it must be observed, that the activity is weakened by the great length of the conductors, especially if they are of an imperfect nature

When the three bodies which form a galvanic circle of the first order are laid one upon the other, so that the lower and upper ones do not touch each other, then these two extremes are in opposite electric states, *viz.* the extremity which is next to that metallic surface that touches the body of the second class is positive, and the opposite extremity is negative. Thus, let copper, zinc, and moistened leather, be laid one upon the other, as in the annexed figure, and the upper end W, *viz.* the moistened leather, will be found possessed of positive electricity; whilst the lower end C, or the copper, will be found negative.

Galvanic Batteries.—Galvanic effects may be increased to almost any degree, by connecting several of the above-mentioned active combinations, or by a repetition of the same simple galvanic combination, (the most active simple combination forming the most powerful batteries, and *vice versa*,) provided the simple combinations are disposed so as not to counteract each other. Those batteries are said to be of the second or first order, according as the simple combinations of which they consist are of the first or second order.

Example. Thus, if a piece of zinc is laid upon a piece of copper, and a piece of moistened card upon the zinc, then a similar arrangement of three other such pieces laid upon them, and a third arrangement upon this, &c. all in the same order, the whole will form a battery of the first order. But if the arrangement is made by connecting a piece of copper with a piece of cloth moistened with water, the latter with a piece of cloth moistened with a solution of sulphuret of potash, and this again with another piece of copper, &c. the whole will form a battery of the second order.

Sir Humphry Davy divides the batteries of the second order into three classes: first, the most feeble, in which metallio plates are so arranged that two of their surfaces or ends opposite to each other are in contact with different fluids, one capable and the other incapable of oxidating the metal. 2dly.

When simple combinations consist of a single plate, each capable of being acted upon by sulphuretted hydrogen, a solution of sulphuret of potash being on one side, and water on the other. 3dly. Metallic substances oxidable in acids, and capable of action on solutions of sulphurets.

Laws of Galvanic Action.—The parts of a battery must not counteract each other. Every simple, but interrupted galvanic combination, has a positive and a negative end, *i. e.* the electric fluid circulates in one way only.

Example. Thus, if two simple combinations are disposed, as in fig. 1, this arrangement will not have any galvanic power, because the actions of the two simple combinations, or the two currents of electricity, are opposed to each other, the two positive ends being called P, and the two negative ends N. But if those fixed bodies are disposed as in fig. 2, then the combination will be very active, because, according to the hypothesis, the direction of the electric fluid in each simple arrangement tends the same way, and probably the one accelerates the other.

Fig. 1.

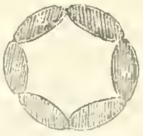
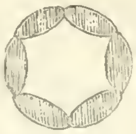


Fig. 2.



What has been said of the above arrangements of the two simple galvanic combinations, must be likewise understood to hold good with respect to the connexion of any number of the same, *viz.* that they must not counteract each other: or if a certain number of them counteract each other, then the remaining only form the active part of the battery. For instance, if a battery consists of forty simple combinations, and if twelve of them are placed in a direction contrary to the others, then these twelve will counteract twelve others, and of course the whole battery will have no more power than if it consisted of sixteen combinations properly disposed.

This points out a method of comparing the powers of two batteries; for if those batteries are connected in an inverted order, *viz.* the positive end of one to touch the negative end of the other; then on connecting the two other extremities, or on applying them to proper instruments, the whole power will be annihilated, if the separate batteries had equal power; otherwise the power of the whole will be the excess of the power of the most powerful battery above that of the weakest; and the direction, *viz.* its being positive or negative, will shew to which battery it belongs. It must be observed, with respect to the inactive arrangement of figure 1, that if one of the separate bodies Z, is removed, then the remaining five bodies will form an active combination, for in that case W W become one body, and S S likewise act as one body.

Construction of Galvanic Batteries.—When three bodies are selected for the battery, the operator has only to make their contact perfect, and the batteries may be of the forms represented by figs 1, 2, 3. Those of figs. 1, 2, are more easily constructed; that of fig. 3, however, is the most commodious.

Fig. 1.

Fig. 2.

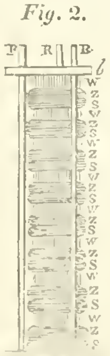
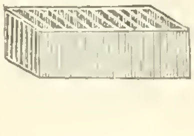
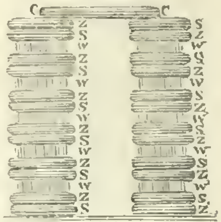


Fig. 3.



The battery fig. 1, consists of several glasses or China cups full of water, or of water containing salt, &c. A plate of zinc and a plate of silver are plunged into the fluid of each cup, excepting the first and last cups; but each of those plates must have a sort of tail or prolongation, by which they are so connected that the silver plate of one cup communicates with the zinc plate of the next, and so on. The battery fig. 2, consists of pieces of silver about the size of half-crowns, pieces of zinc of about an equal size to those of the silver, and pieces of card or cloth, leather, or other bibulous substance, a little smaller in diameter than the metallic pieces, and soaked in water or in any other proper fluid. These pieces are disposed in the order silver, zinc, and wet cloth, as indicated by the letters S, Z, W. The pieces of card or cloth, &c. must be well soaked in the fluids; but before they are applied, they should be squeezed, in order that the superfluous fluid may not run down the outside of the pile, or insinuate itself between the contiguous pieces of silver and zinc. Those pieces especially, if soaked in common water, lose their moisture pretty soon, so that they can hardly serve longer than for a day or two; after which time the pile must be deranged, the metallic pieces cleaned, those of cloth or card soaked again, and the whole arranged as before. The three rods, R, R, R, are of glass or of baked wood, and the piece of wood, O, slides freely up or down the rods. This serves to prevent the falling of the pieces. When such a battery is to be very powerful, that is to say, when it is to consist of numerous pieces, the best way is to form two or more piles, and to join them by pieces of metal, as C C, in fig. 4, where two piles are joined together, so that *a* is the negative extremity, and *b* is the positive one of the whole arrangement, or of the two piles, *a* considered as one. The battery, fig. 3, consists of a strong oblong vessel of baked wood or porcelain, about three inches deep, and as much broad. In the side of this vessel grooves are made opposite to each other, and about one-eighth of an inch in depth. In each pair of opposite grooves a double metallic plate, *viz.* a plate of zinc and a plate of silver soldered together at their edges, are cemented, or the plates may be put in, connected only at their upper ends; by which means the wooden vessel is divided into several cells or partitions, about half an inch wide, as is indicated by the figure. The cementation of the metallic pieces into the sides and the bottom of the wooden vessel, must be so accurate as not to permit the passage of any fluid from one cell into the next. The cement proper for this purpose, is made by melting together five parts of resin, four parts of bees-wax, and two parts of powdered red-ochre. Those cells are afterwards filled almost to the top with water, or any other fluid, according to the foregoing table, and thus the whole will form a battery, consisting of various repetitions of silver, zinc, and fluid. Two or more of such batteries may be joined, as was said of the preceding battery.

Fig. 4.

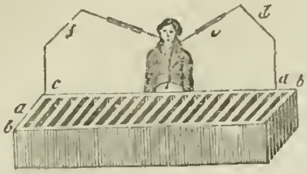


It need hardly be observed, that instead of zinc, copper, and water, other combinations may be made according to the table. At present, the last described batteries are constructed with copper, zinc, and water mixed with a small portion of nitric or muriatic acid. For the construction of such batteries it is of little consequence whether the materials are pure or slightly alloyed. The action of all these batteries is greatest when they are first completed or filled with any fluid; and it declines in proportion as the metal is oxidated or the fluid loses its power. Hence, after a certain time, the fluid must not only be changed, but the pieces must be cleaned, by removing the oxidated surface, which is done either by filing or rubbing them with sand, or sand paper, or by immersing them for a short time in diluted muriatic acid, and then wiping them with a coarse cloth. The metallic pieces of fig. 4, may be cleaned by the last method, and wiped by introducing a stick with a rag into the cells. The energy of galvanic batteries, when the troughs are porcelain, may be restored by merely lifting out the metals, and exposing them to the action of the atmosphere. This much may be sufficient with respect to the construction of simple and compound galvanic arrangements.

Galvanic Experiments.—Experiment 1. When the galvanic battery of the first order consists of twenty repetitions of simple combinations, and if with one hand one extremity of a battery be touched, and the other hand be applied to the other extremity of the battery, a shock will be felt, like that which is communicated by a Leyden phial weakly charged, and it will hardly be felt beyond the fingers, or at most the wrists. This shock will be felt as often as the contact is repeated.

Note.—The battery in the following experiment, is the form of that most usually sold by the philosophical instrument makers. The nitric and muriatic acid may be had at any chemist's shop.

Fig. 1.



2. If the hands are continued in contact with the extremities *b* and *a*, a slight but continued irritation will be perceived; and when the hand which touches the extremity of the battery is excoriated or wounded, this sensation is disagreeable, and rather painful.

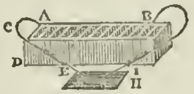
3. Instead of one person, several persons may join hands, (well moistened with water,) and on completing the circuit, they will all feel the shock at the same instant. But the strength of the shock is much diminished, by its passing through the several persons, or, in general, by passing through less perfect conductors.

4. The shock from a battery consisting of fifty or sixty repetitions, of the most active combinations of the first order, may be felt as far as the elbows, and the combined force of five or six such batteries will give a shock much stronger, perhaps, than most men would be willing to receive. The prepared limbs of a frog or other animal are violently convulsed; but soon exhausted of their irritability by the action of a galvanic battery, and its action on a person lately executed at Glasgow was the most singularly terrific that medical practitioners had ever witnessed.

5. If a wire, proceeding from one extremity of a pretty strong battery, is made to communicate with the inside coating; and a wire which proceeds from the other extremity of the battery is made to communicate with the outside coating of a common large jar or electrical battery; the latter will become weakly, but almost instantaneously, charged in the same manner as if it had been charged by a few turns of a common electrical machine; with this charge you may either give the shock or effect on the electrometer.

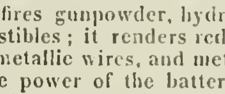
6. The spark, or the discharge of a galvanic battery, when sent through thin inflammable bodies that are in contact with common air, or oxygen gas, sets them on fire and consumes them with wonderful activity. It fires gunpowder, hydrogen gas, phosphorus, and other combustibles; it renders red-hot, fuses, and oxidates very slender metallic wires, and metallic leaves. The mode of applying the power of the battery for such purposes, is shewn in fig. 2, where A B represents a powerful galvanic battery; A C D F, is a wire which communicates with the last plate of the battery at A; B K H G is another wire which communicates with the last plate at B. D E, H I, are two glass tubes, through which those wires pass, and into which they are fastened sufficiently steady. Those tubes serve to move the wires; for if the operator applies his fingers to those tubes, he may move the wires wherever he pleases, without the fear of receiving a shock. If the two extremities F G, are brought sufficiently near to one another, the spark will be seen between them. It is between those extremities that the combustible substances, or the metallic leaf, is to be placed in order to be fired or burned. This figure, moreover, represents the situation of the wires in the act of inflaming gunpowder.

Fig. 2.



7. A battery consisting of 200 pairs of metallic plates (*viz.* copper and zinc, each five inches square) melted 23 inches of very fine iron wire. A platina wire about $\frac{1}{13}$ inch in diameter, was melted into a globule. Fig. 3, is the representation of a compound battery of the same kind, fastened together with iron cramps *a*, *b*, *c*. Under the exhausted receiver of the air pump, the galvanic battery acts less powerfully than in the open air; but in oxygen gas, it acts with increased power.

Fig. 3.



8. The flash of light, which appears before the eye of the experimenter, when the eye itself or some other part not very remote from it, is put in the circuit of a galvanic combination, does not appear much greater when a battery is employed than when two plates are applied in the manner which has been already mentioned; but when the battery is used, the sensation of a flash may be produced in various ways. If one hand or both be placed in contact with one extremity of the battery, and almost any part of the face brought into contact with the other extremity, the flash will appear very distinctly, the experimenter being in the dark, or keeping his eyes shut. This flash appears very strong, when a wire which proceeds from one extremity of the battery, is held between the teeth, and rests upon the tongue, whilst the other wire is held in the hand. In this case, the lips and tongue are convulsed, the flash appears before the eyes, and a very pungent taste is perceived in the mouth.

9. If any part of the human body, forming part of the circuit of a galvanic battery, is kept sometimes in that situation, the irritation is more or less distinct, according to the sensibility of the parts concerned. This application is likely to prove most useful as a remedy in various disorders. It is said, that it has already proved most beneficial in deafness and in rheumatisms.

Decomposition of Compound Bodies.—The most extraordinary phenomena of galvanic batteries, are the chemical effects produced upon bodies placed in a circuit. Thus, when into two small tubes, connected by a moist animal substance, and filled with distilled water, two gold wires are introduced from a large battery in the proper order, oxygen is produced in one quantity of water and hydrogen in the other, nearly in the proportions in which they are required to form water by combustion. All the oxygenated solutions of bodies possessing less affinity for oxygen than nascent hydrogen, are decomposed when exposed to the action of the metal occupying the place of the least oxidable part of the series in the compound circle. Thus we may produce sulphur from sulphuric acid; and precipitate copper and other metals in the metallic form, from their solutions.

On bringing potash and soda within the action of a powerful battery, Sir H. Davy found that metalline substances were produced, which he has named *potassium* and *sodium*.

It is well known, that hydrogen in its nascent state, reduces the oxide of metals. Accordingly, when a tube is filled with a solution of acetate of lead in distilled water, and a communication is made with the battery, as above described, no gas is perceived to issue from the wire which proceeds from the negative end of the battery; but, in a few minutes, beautiful metallic needles are perceived on the extremity of this wire; they soon increase, and assume the form of a fern leaf, or other vegetable. The lead thus separated, is in its perfect metallic state, and very brilliant. When a solution of sulphate of copper is employed, the copper is precipitated in its metallic state; but instead of appearing in crystals, it forms a kind of button, which adheres firmly to the end of the wire. The effects of the galvanic battery upon the human frame when dead, are extraordinary, but of these we cannot now treat.

Improvement in the Galvanic Battery.—Professor Oersted, among his other discoveries on the affinity between electricity and galvanism, has ascertained the important fact, that to produce an active influence on the magnetic needle, and divert it from its position, exposing it to the action of a single pair of discs of copper and zinc, separated by a conducting body, will be sufficient; and that this simple apparatus will act with more force than an entire pile. By this simplification of the galvanic process, he has suspended two plates of copper and zinc separated by a liquid conductor, to a very fine thread; and he has found this arrangement competent to give them a higher degree of mobility, and to render them susceptible of obeying or yielding to the action of exterior agents however feeble. Little bars, strongly magnetized, presenting either of their poles to the apparatus, repulsed or attracted it, imparting a rotatory movement about the point of suspension.

GAMBOGE, a concreted vegetable juice, partly of a gummy and partly of a resinous quality, brought from India.

GAME, in general, signifies any diversion or sport performed with regularity, or restrained to rules. Games are usually distinguished into those of address and those of hazard. To the first belong chess, tenis, billiards, wrestling, &c. and to the latter those performed with cards or dice, as backgammon, ombre, picquet, whist, &c.

Games, in Antiquity, were public diversions, exhibited on solemn occasions. Such, among the Greeks, were the Olympic, Pythian, Nemæan, &c. games; and among the Romans, the Apollinarian, Circensian, Capitoline, &c. games. The Romans had three sorts of games, *viz.* sacred, honorary, and ludicrous. The first were instituted in honour of some deity or hero: of which kind were those already mentioned, together with the augustalis, doralis, palatini, &c. The second were those exhibited by private persons to please the people, as the combats of gladiators, the scenic games, and other amphitheatrical sports. The ludicrous games were much of the same nature with the games of exercise and hazard among us; such were the ludus trojanus, tesseræ, tali, trochus, &c.

Game. It is a maxim of the common law, that goods of which no person can claim any property, belong to the king: hence those animals, (feræ naturæ,) which come under the denomination of game, are styled in our laws his majesty's game; and that which he has, he may grant to another; in consequence of which, another may prescribe to have the same within such a precinct or lordship. And hence originated the right of lords of manors, or others, to the game within their respective liberties. For the preservation of these species of animals, for the recreation and amusement of persons of fortune, to whom the king has granted the same, various acts of parliament have been made. To entitle any one to kill game, he must now take out a certificate, upon which a stamp duty is payable. There are innumerable acts of parliament inflicting penalties on persons illegally killing game, and some of them exceedingly severe, extending even to transportation. Yet, whilst so many persons of great wealth have not otherwise the means of procuring game except by purchase, and are desirous of having it, the encouragement thus given to poaching will continue to render all game laws nugatory as to the effect intended. It is not lawful for qualified persons to kill game at all seasons. The time for sporting, in the day, is from one hour before sun-rising, until one hour after sun-setting. 10 Geo. III. c. 10. For bustards, the sporting is from Dec. 1 to March 1. For grouse, or red grouse, from Aug. 11 to Dec. 10. Hares may be killed all the year under the restrictions in 10 Geo. III. c. 19. Heath fowl, or black game, from Aug. 20 to Dec. 20. Partridges, from Sept. 1 to Feb. 12. Pheasants, from Oct. 1 to Feb. 1. Widgeons, wild ducks, wild geese, wild fowls, at any time but in June, July, August, and September.

GAMELION, in Ancient Chronology, was the eighth month of the Athenian year, containing 29 days, and answering to the latter part of our January and beginning of February.

GAMING, Laws of. These are founded on the doctrine of chances. De Moivre, in his treatise De Mensura Sortis, has computed the variety of chances in several cases that occur in gaming, the laws of which may be understood by what follows. Suppose p the number of cases in which an event may happen, and q the number of cases wherein it may not happen, both sides have the degree of probability, which is to each other as p to q. If two gamesters, A and B, engage on this footing, that if the cases p happen A shall win; but if q happen, B shall win, and the stake be a; the chance of A will be $\frac{p\,a}{p+q}$, and that of B $\frac{q\,a}{p+q}$; hence, if they sell the expectancies, they should have that for them respectively. *See* Chances.

GAMMONING, seven or eight turns of a rope, passed over the bowsprit, and through a large hole in the stem or knee of the head, alternately, and serving to bind the inner quarter of the bowsprit close down to the ship's stem, in order to enable it the better to support the stays of the foremast; after all the turns are drawn as firm as possible, the opposite ones are braced together under the bowsprit by a frapping.

GAMUT, or Gam-ut, in Music, a scale on which we may learn to sound the musical notes *ut, re, mi, fa, sol, la,* in their several orders and dispositions.

GANG, a select number of a ship's crew appointed on any particular service, and commanded by an officer suitable to the occasion.

Gang *Board*, a plank or board, with several cleats or steps nailed to it, for the convenience of walking into or out of a boat upon the shore, where the water is not deep enough to float the boat close to the landing place.

Gang, or *Gangue*, in Mineralogy, is a word used by German mineralogists to denote a metallic vein. But according to the French, it denotes the stony matter which accompanies the ore in the vein.

GANGRENE, is a great and dangerous degree of inflammation wherein the parts begin to be in a state of mortification.

GANGWAY, a narrow platform, or range of planks, laid horizontally along the upper part of a ship's side, from the quarter deck to the forecastle, and is peculiar to ships that are deep waisted, for the convenience of walking more expeditiously fore and aft, than by descending into the waist: it is fenced on the outside by iron stanchions, and ropes or rails, and in vessels of war with a netting, in which part of the hammocks are stowed. In merchant ships, it is frequently called the *gang-board*.

Gangway, is also that part of a ship's side, both within and without, by which persons enter and depart; it is provided with a sufficient number of steps, or cleats, nailed upon the ship's side, nearly as low as the surface of the water, and sometimes furnished with a railed accommodation ladder, resembling a flight of stairs projecting from the ship's side, and secured by iron braces.

Gangway, is also used to signify a narrow passage left in the hold when a ship is laden, in order to enter any particular place as occasion may require, whether to examine the situation of the provisions or cargo; to discover and stop a leak, or to bring out any article that is wanted. Finally, *Gangway* implies a thoroughfare, or narrow passage of any kind.

To bring to the Gangway, a phrase signifying to punish a seaman by seizing him up and flogging him with a cat-o'-nine-tails

GANTLOPE, or Gauntlope, vulgarly pronounced *Gantlet*, a race which a criminal is sentenced to run in a vessel of war, for felony, or some other heinous offence. It is executed in the following manner:—The whole ship's crew is disposed in two rows, standing face to face on both sides the deck, so as to form a line whereby to go forward on one side and aft on the other, each person being furnished with a small twisted cord called a *knittle*, having two or three knots upon it; the delinquent is then stripped naked above the waist, and ordered to pass forward between the two rows of men on one side and aft on the other side, a certain number of times, rarely exceeding three, during which every person gives him stripes as he runs along; in his passage he is sometimes tripped up and severely handled while incapable of proceeding; this punishment, which is called *running the gantlet*, is seldom inflicted except for such crimes as naturally excite general antipathy amongst the seamen.

GARBOARD-STREAK, the first range or streak of planks laid upon a ship's bottom, next the keel, throughout the whole length of the floor. The edge of this plank is let into a groove or channel in the side of the keel, which is called the rabbet of the garboard-streak.

GARDENING. This art, so natural to man, may be divided into two branches, practical and picturesque. A garden, properly speaking, is a small spot of ground attached to the house. As the house is itself a regular and formal object, so we naturally expect something of the same regularity in this appendage. Neatness too is one of the chief excellences of a garden, and this is wholly inconsistent with a rage for the picturesque. *See* Loudon's Cyclopædia of Gardening.

The situation of a garden should be dry, rather low than high, and sheltered from the north and east winds. These points of the compass should be guarded against by a wall ten feet high; lower walls do not answer so well for fruit trees. A garden should be so situated, as to be as much warmer as possible than the general temper of the air is without, or ought to be made warmer by the ring and subdivision fences. A garden may be square, but an oblong is preferred, and the area rather a level; or if there is a slope it should, be southward, a point either to the east or west not much signifying; but not to the north, if it can be avoided, because crops come in late, and plants do not stand the winter so well in such a situation. A garden with a northern aspect has advantages, being cooler for some summer productions.

The best soil for general cultivation is a loam, rather red than black. The worst is a cold heavy clay, and the next a light sand; a moderate clay, however, is better than a light soil, though not so pleasant to work. The aspect of the wall designed for the best fruits may be full south; or inclining to east, by which it will catch the sun's rays at its rise, the cold night-dews be earlier dissipated, and the scorching rays of the afternoon sun are sooner off. By thus having the walls of a garden not directly to the four points, the north wall is greatly advantaged by having more run.

The border next this wall should be of good earth, about two feet deep, rising a little towards the wall. A free moderate loam, or some fresh maiden soil, not too light, is essential to make the borders promising good; and in order to this, if manure is necessary, let it be that of rotted vegetables, or turf, with wood ashes; for the roots of fruit-trees should not meet with much dung, at least of horses; that of cows is the best, or that of sheep or hogs will do well rotted, well mixed, &c. being worked in the borders as long as possible before the trees are planted.

If a garden is large and square, a second south wall, running down the middle of it, would be useful; and so, if large and long, a cross wall or two might be adopted, as giving opportunity for the cultivation of more trained fruit-trees; and if there is any idea of forcing fruits, these intersecting walls, ranging east and west, are proper for it, (as situated within the ring fence,) furnished with flues, &c. The best fruit border being prepared for peaches, nectarines, and apricots, or vines and figs, the trees should take their residence there, (if the leaf is falling,) about the latter part of October. If the middle of December is past, February is then the time; though gardeners plant all winter, if the weather is open enough to work the ground. March, however, may do, or even the beginning of April.

Wall trees should not be older than two years from grafting or budding. Except in fine situations, never plant early and late peaches; as the first may be cut off, and the latter not ripen. The distance to plant should be about twelve inches from the wall: and let apricots, peaches, and nectarines be twenty feet asunder, or according to the height of the wall; though for the small early sorts fifteen or sixteen feet will do. As the larger apricots, however, grow freely, and do not well endure the knife, they ought to have twenty-five feet allowed them. This is for a wall nine or ten feet high; if higher, the distance may be less, and if lower, the contrary. Fig trees require as much room as the apricot, or rather more; as they grow freely, and are to extend without shortening. Though other trees are best planted in October, the fig should not be till March. The intermediate spaces between peaches, nectarines, and apricots, may have a vine, a dwarf cherry, or currant or gooseberry tree of the early sorts, as the smooth green and small red, to come in early. But wherever grapes can be expected to ripen, there let a young plant or cutting be set, though the space should be confined; for the vine, freely as it shoots, bears the knife well to keep it within bounds. If the wall is high, the cherry or plum may be half-standards; which being after a while kept above, will be more out of the way of the principal trees; though dwarfs may be trained so as not to interfere. Some have planted half-standards of the same kind of fruit as the dwarfs; but whichever mode is adopted, let the intermediate trees be pruned away below in good time, in order to accommodate the principals freely as they mount and extend.

Plums, cherries, and pears, may occupy the other walls; the two former at about fifteen feet, or it may be twenty feet asunder. Cherries, except the morella, will not do well in a full north aspect; but any sort of plum (rather a late one) and summer pears, and also nut trees, will, if you choose to train them. There should always be some currants and gooseberries in an east and north situation, at the distance of eight feet, where they will be easily matted, when ripe, to come in late, as October, November, or perhaps December. Pear trees of free growth are hardly to be kept within tolerable compass on low walls; but if attempted, should have at least thirty feet allowed them. The best sorts of winter pears deserve a southerly wall to ripen them well, and improve them in size and flavour. The gable end of a house is well adapted for a pear-tree, as it affords room, which they require. Apples may do well on a wall, (and if any on a good wall, let it be the golden pippin,) yet the practice is seldom adopted. For furnishing walls, choose trees of moderate wood, young, well rooted, clean, and healthy.

When the planting of a garden is finished, it will be a good way to have a plan of it taken, with the name of every peculiar tree marked on it in its place, to be assured of the sorts when they come to bear. Here it may be observed, that if any evergreen hedges are desired in or about the garden, yew, box, alaternus celastrus, phillyrea, and pyracantha, may be kept low, and clipped in form, if so desired; in addition to which, if a few roses were intermixed, it would have a very pretty effect. A deciduous hedge for subdivision, or screen, &c. may be made of elms or limes, setting the larger plants at five feet asunder, and a smaller one between. Or an ordinary fence, or subdivision, may be quickly formed of elder cuttings, stuck in at two feet asunder, which may be kept cut within bounds.

A wide body next the south wall, as was said, is best for the trees; and moreover, for the many uses that may be made of it for the smaller early, or late tender esculents, and a few earlier cauliflowers. For the sake of a pleasant warm walk in spring, to have the south border narrow may be desirable; but on no account let it be less than six feet. Take care that this walk is not sunk too much; and that it have a bottom of good earth, as deep as where the trees are planted. Let the body of gravel be thin, and then the roots of the trees will be admitted to run properly under the walk, and find wholesome nourishment; where, if they were stopped by rubbish, they would be apt to canker, and irrevocably disease the trees. The number and breadth of the walks must in a measure be determined by the quantity of allotted ground; exceeding in these particulars where there is room. But few and wide walks are better than many and contracted. If edgings are to be made, in order to separate between the earth and gravel, especially if of stone or wood, or box, they should be done first, and they will be a good rule to lay the box by. Grass walks may answer where gravel is scarce. Camomile has been also used to form green or carpet walks, planting it in sets about nine or ten inches asunder; which naturally spreading, the runners are fixed by walking on them, or rolling. Sand may be adopted for walks, but lay not any of it too thick, as it is the less firm for it. Coal-ashes strewed thinly in the alleys are better than nothing, as they at least serve to keep the feet dry. Sea-shells make very good walks.

All trees designed to be planted are to be thought of before winter. Those of the wall have been spoken of; and as to standards, they must have a fair depth of good soil to grow in; for it should be remembered, that tree roots in a garden are prevented from running over the surface, as they do in an undisturbed orchard. It is necessary that some caution should be used not to dig the ground too near and too deep about garden trees, lest, loosening the roots, they should not be able to stand the wind; and because the nearer the surface any root grows, the more and choicer fruit the tree bears. But the fewer standard trees in a garden the better, as they take up much room, and by their shade prevent the proper growth of vegetables that are near them; so that if a garden is small there should be no trees except those of the wall. The case is different where there is ample room; and the blossoms of fruit trees are so delightful, that if they produced nothing for the palate, there would be a sufficient inducement to plant them for ornament; but let them be dwarf standards in preference to espaliers.

Dwarf standards occasion less trouble to keep them in order than espaliers, and are generally more productive; for espalier trees are seldom managed well, and thus appear unsightly: at best they are stiff and formal, and obstruct the sight in viewing the quarters of a garden, which, if in order, are worthy of coming under the eye.

If any espaliers are planted, let them be only fruit of the best sorts, and in spacious gardens, where they may have a good length and height allowed them to grow freely. They should rather be trained to sawed materials properly framed together, smoothed and painted. But for a year or two they may be fastened to light stakes, when they will have formed a head, to begin to train them for bearing in the neat manner proposed, that is, to slips of deal joined to light oak posts, as trellises. Whether the slips are placed perpendicularly or longitudinally, seems indifferent. If the longitudinal mode of training is the best approved, strong iron wire may be recommended to run through the posts instead of slips of wood, as it shades less, and is stronger and neater. If upright slips are used, they should be slender, and from six to eight inches distant, according to the greater or less freedom of the natural growth of the tree.

Apples should be allowed 24 feet, and pears 30, except those grafted on paradise or quince stock, for which little more than half this distance may answer. Cherries and plums should have about 18 or 20 feet allowed them. Quinces, medlars, mulberries, and filberds, may also be espaliered. The trees should be planted about a yard from the edge, but farther off is better, if the walks lie deep of gravel or poor materials.

Currants, gooseberries, and raspberries, do well espaliered, as to a production of early and fine fruit.

Trees of a more humble nature, and shrubs, next occupy attention in furnishing a garden. Currants and gooseberries (as bushes) should be planted three feet from the edge, and full six feet asunder. Some of these very useful shrubs should grow in every aspect of the garden, in order to have a succession of their fruits as long as may be. Those who choose to plant whole quarters of currants and gooseberries, ought to do it at six feet asunder in the rows, and the rows eight feet from one another.

Raspberries may be set in plantations, in rows five feet asunder, allowing three feet between the plants. These shrubs are always best by themselves, as otherwise their suckers over-run the quarters. Between rows of raspberries planted at the above distance, coleworts, early cabbages, cauliflowers, and lettuces may be set, or spinach sowed in drills; the raspberries having had their pruning and dressing early in autumn for the purpose. Every year, a little short manure, dug in close about the roots, (and deeper as the plantation gets older,) will ensure fine fruit. Raspberries are not very nice as to soil and situation. The smooth-wooded or cane-rasp is to be preferred for a principal crop. The large, white, or Antwerp, is also good.

Strawberries may be planted at the edges of borders and quarters, either in single or double rows, (rather the latter) for the convenience of gathering, and for ornament, but the common and best way is, in four-feet beds, with eighteen-inch or two-feet alleys, on which beds may be five rows of the wood and alpine, four of the scarlet and pine-apple, three of the Carolina, and two of the Chili; setting the plants at the same distance in the rows as the rows are from one another in the quincunx order. In a good, cool, loamy soil, which suits them best, a little more distance may be allowed the first four sorts; and in a quite dry light soil, somewhat less, that they may shade one another the better from drought. The best situation for strawberries is an open and sunny one, as thus they bear more and finer-flavoured fruit. Some of the scarlets should be planted under warm walls, to come early. The woods bear shade as natural to them, and the alpines do tolerably well in it. The most proper time for planting the strawberry is the first moist weather in September, (or even earlier,) that they may be established in the ground before winter, and they will bear the better the first year. Frost is apt to throw up late-planted ones, and injures if not destroys them. Those planted in spring often suffer from drought, and bear very little the first year, except the alpines. Choose forward runners for planting, and let them be from beds in full bearing, that is, of two or three years old, for plants from old beds are not so fruitful. Press the mould to the roots, give them a watering, and again once or twice if the weather proves dry. Some gardeners let them run over the beds, which in a dry light soil may be proper; but in this case, a greater distance should be allowed them at planting. If the alpine sort is planted on a warm border, eighteen inches asunder, and suffered to spread, the first runners will fruit the same year, and sometimes this prolific strawberry bears till November.

Fresh plantations of strawberries should be made every fourth year, though in a good soil, and with good management, they will continue longer; so that where they are suffered to run, the plants being frequently renewed, and old ones removed, beds have borne tolerably for ten years. The watering of strawberries should not be neglected, doing it almost daily when in flower, and setting their fruit, if the weather proves dry, particularly to those under a warm wall; but this is not to be continued when the fruit is nearly ripe.

Flowering shrubs may be dispersed about, and herbaceous perennial flowers; but plant them not too near the edge, lest they hang over the walks. The bulbous sort may, however, be within six inches, especially crocuses and snow-drops.

Asparagus and artichokes take up much room, and in small gardens may therefore be left out. It will be of little use to have less than 50 or 60 feet of asparagus-beds, as there would be so few heads to cut at a time; and artichokes must be planted wide. Let not potherbs be forgotten, but provide a general herbary in that part of the garden which is warmest, and best shaded, for these are tender plants.

Having spoken of stationary things, the routine of the seasons must dictate the rest; and the inclinations of the palate will refresh the memory to take care of providing the most necessary and agreeable esculents for dressing, and raw salads.

Perennial flowers have been mentioned; but let fancy direct as many annuals and biennials to be cultivated, as room can conveniently be found for, that the garden may be as much as possible ornamented.

In furnishing a garden with shrubs and flowers, respect should be had to their usual height, their bulk, colour, and season, that the mixture may be properly varied, harmonious to the eye, and come in regular succession. The latter part of the year is seldom provided for so well as it might be; late flowers should be set in warm situations, as their proper place. In the most dreary months, by judicious planting, evergreens in their neat and cheerful "winter liveries," may be viewed from our windows, and serve instead of flowers.

Those who garden upon a large scale, should take care to have every thing proper and convenient liberally provided. Let there be a well-situated place for hot-beds, with some building as a tool house, and (if dry) for keeping bulbs, seeds, and herbs. Those also who garden even upon a small scale, will do well to have every needful implement. If water can be introduced and kept clean with verdant banks around it, it would be found very useful where a garden is large; but let it be as near the centre as possible, as the most convenient situation. It should be fed from a pond in preference to a spring.

Mixed gardening, as comprehending the profitable with the pleasant, has been the subject hitherto; but if the flower garden and the kitchen garden are to be distinct, the case is altered; not so much indeed, but that still the kitchen garden should be adorned with a sprinkling of the more ordinary decorations, to skirt the quarters, chiefly those of the most powerful sweet scents, as roses, sweetbriars, and honeysuckles, wall-flowers, stocks, pinks, mignonet.

The Flower-garden, properly so called, should be rather small than large; and if a separate portion of ground is appropriated for this, only the choicest flowers should be introduced, and cultivated in the best manner. The beds of this garden should be narrow, and consequently the walks numerous; and not more than one-half or two-thirds the width of the beds. except one principal walk, all round, which may be a little wider. The gravel, or whatever the walks are made of, should lie about four inches below the edge. The beds for tulips, hyacinths, anemones, ranunculuses, &c. may be three and a half or four feet wide, and those for single flowers the same, or only two and a half feet wide in the borders. Let the beds lie rather rounded in the middle, but the walks flat. Figured parterres have got out of fashion, as a taste for open and extensive gardening has prevailed; but when the beds are not too fanciful, but regular in their shapes, and chiefly at right angles, after the Chinese manner, an assemblage of all sorts of flowers, in a fancy spot of about 60 feet square, is a delightful home source of pleasure, worthy of pursuit. There should be neat edgings of box to these beds, or rather of neat inch boards, painted lead colour, to keep up the mould. Be sure to keep the box from the very first, as soon as rooted, and always after, as low as possible; clip it twice a year, April and July.

Landscape or Picturesque Gardening, is so much the work of fancy, and so much depends upon the situation, or what Brown and Loudon call the capability of the place, that that no precise rules can be laid down concerning it. All, therefore, that can be expected, is a few loose hints, on which the man of taste may improve according to circumstances. The pleasure we seek in laying out gardens, is now justly founded upon the principles of concealed art, which appears like nature; but still, whether ingenious contrivances, and decorations, (altogether artificial,) should be so entirely laid aside as they are, may deserve to be considered. Perhaps the works of the statuary might still be introduced, if well executed, and in proper places. A terrace, as a boundary, is now seldom formed, but in some situations such an eminence might in several respects be agreeable.

If trees are planted injudiciously, the error is a trifle, but if cut down so, the consequence is serious, and has often been sorely lamented; extirpation should therefore be well thought of before it is executed, especially trees about houses, for many dwellings have been thus too hastily exposed, and deprived of comfortable shelter and shade. Hilly spots that are in view of the house should be planted with firs, as fine looking trees, and very hardy. Beech does well on high ground, especially if chalky. In low ground, not to mention alders, and that tribe, the birch, and even the oak, should not be forgotten, where the wet does not long stand.

About the house some shady walks ought always to be provided, by thick planting, if not of trees, yet of flowering shrubs, and evergreens, of which the laurel will be found the most useful. Those who have much space of ground to decorate, do well to plant trees, and shrubs of every kind, as enlarging the sources of amusement: but if the allotment of ground for this purpose is contracted, then, of course, those only should be planted which by their neat foliage, natural symmetry, and gay flowers, may be truly esteemed ornamental. The walks should always be wide, some inclining to serpentine, and contrived as much as possible upon a level, as walking up and down hills can hardly be called pleasure. That they may be extensive, they should skirt the grounds and seldom go across them. In small pleasure grounds the edges of the walks should be regularly planted with flowers, and long ones occasionally so, or with the most dwarf shrubs; and neat sheltered compartments of flowers (every now and then to be met with) have a pretty effect. If the walks are extended to distant plantations of forest-trees, every opportunity should be taken to introduce something of the herbaceous flowery kind, which will prove the more pleasing, as found in unexpected situations. The outer walk of pleasure grounds and plantations should every now and then break into open views of the country, and to parts of the internal space, made pleasing, if not striking, by some work of art, or decoration of nature.

Water should only be introduced where it will run itself clear, or may be easily kept so, as also in full sight; and some fall of it should be contrived, (if possible) for the sake of giving it motion and sound, because a lively scene of this element is always much more pleasant than a dead one. Near some pieces of water, as a cool retreat, it is desirable that there should be something of the summer-house kind; or a simple rustic arbour, embowered with the woodbine, the sweetbriar, the jessamine, and the rose.

Before the design of a rural and extensive garden is put in execution, it ought to be considered, or anticipated what it will be in twenty or thirty years' time; for it often happens, that a design which looks handsome when first planted, and in good proportion, becomes so small and ridiculous in process of time, that there is a necessity either to alter it or destroy it entirely, and so plant it anew. Landscape gardening depends much on the form of the ground, and therefore to shape that is the first object. Too much plane is to be guarded against; and when it abounds, the eye should be relieved by clumps, or some other agreeable object. Hollows are not easily filled; and eminences mostly are advantageous in the formation of picturesque scenes, in which the general principle of ornamental gardening consists.

To plant picturesquely, a knowledge of the characteristic differences of trees and shrubs is evidently a principal qualification. To range the shrubs and small trees, so that they mutually set off the beauties, and conceal the blemishes, of each other; to aim at no effects which depend on a nicety for their success, and which the soil, the exposure, or the season of the year, may destroy; to attend more to the groups than to the individuals; and to consider the whole as a plantation, not as a collection of plants; are the best general rules which can be given concerning them.

The Cultivation of a Garden.—The first object with a view to produce should be, to keep the ground in such a state as will enable it to produce good crops. Good vegetables cannot be had without good manure. Yet raw unwrought dung is not good for a garden. The most economical plan, therefore, that can be pursued, is for the first year to make good hotbeds of your dung, and spread it out upon the quarters, and dig it in autumn and winter. You by this means have a double produce, and the dung is the better.

Dung, however, used in great quantities, and lying in lumps, breeds worms, grubs, and other insects, and causes plants to grow too rampant and rank-flavoured. Carrots it cankers, and it disagrees with many things. On these accounts some persons have been induced to dress their gardens only with rich fresh earth. If the ground is in proper heart, every spot may be contrived to be constantly and successfully cropped, as each sort of plant draws a somewhat different nourishment; so that after a full crop of one plant, one of another kind may often be immediately sown; but it should be contrived that a wide crop may follow a close one, and contrariwise. Close crops, as onions, leeks, carrots, &c. are conveniently and neatly cultivated in beds of from four to five feet width, with alleys of from a foot to eighteen inches between them.

The seasons proper for furnishing the ground with every particular vegetable, should be well attended to, that each may be obtained as early as its nature will permit; and of the seeds and plants we use, care must be taken to procure the best of the kind, lest after all the trouble of cultivation, disappointment, as to quality, should ensue. Seeds and plants should be adapted as much as possible to the soil and situation which best suits them. The thinning of seedling crops should be done in time, before the young plants have drawn one another up too much. All plants grow stronger and ripen better, when the air circulates freely round them, and the sun is not prevented from an immediate influence.

In the pricking and planting of crops, be sure to do it as early as may be; let every thing be regular. Shading of new planted things, particularly flowers, is of much benefit, and that in proportion as the season is sunny.

Strawberries and cauliflowers are generally watered in a dry season; that is, the strawberries when in bloom, in order to set the fruit, and the cauliflowers when they shew fruit, in order to swell the head. In very dry weather, asparagus seedlings, early turnips, carrots, radishes, and small salads, will need watering. Slips, cuttings, and layers of any kind, will need water. Pots of flowers must have it frequently.

When watering is undertaken, let it be a complete business, *i. e.* to the bottom and extent of the roots, as much as may be. Wetting the surface of the ground, however, in a summer's evening, makes a cool atmosphere; a dew is formed, which pervades the leaves, and helps to fill their exhausted vessels.

Watering the roots of wall trees, (if dry weather,) when the fruit is setting, is by some thought necessary. To young trees only it can, however, be of use, for the roots of old ones run far and wide; and it is the small fibres of these distant roots on which the tree chiefly depends for food. Vines should have no water till they are off blossom, (July) and the fruit as big as large pins' heads; and then, if the season is very hot and dry, watering the roots twice a week will help the fruit to swell. As watering is apt to make the ground hidebound and unsightly, let the surface be occasionally stirred and raked, which will make future waterings enter the ground the better. Many things are impatient of being kept wet about the shanks, and therefore watering should be generally at a little distance. Rain water is the best for watering, as appears by the verdure and vivacity it gives. Pond water is next in fitness, and river water follows. Well water is of least account, though local circumstances occasion its use the most. Pump water, if used directly, is so cold in summer, that it is found prejudicial to plants; and great cold so contracts their vessels, that they perform their proper offices with difficulty, and become diseased.

The management of a garden, as somewhat distinct from the cultivation of it, is an object of consequence; that is, to keep it in such order, that it may not fail in those general impressions of pleasure it is capable of affording, when things are shewn in their best manner. A garden may be cultivated so as to be profitable, and yet not conducted so as to be agreeable to walk in, which, in a private garden, is a circumstance surely to be lamented. The proper appearance of a well-managed one is expressed by the word *neat*. Let all be done that can be in order to it. To be neat, weeding must be industriously followed up, and all litter that is made in working, quickly carried off. The ground also should be frequently stirred and raked between crops, and about the borders, to give all a fresh appearance. There is a pleasantness to the eye in new broken earth; and when there are no flowers left in the borders, this gives an air of culture, and is always agreeable. An asparagus fork is expeditious and useful in this case; but it must be slightly used, lest it disturb the roots of plants too much. Vegetables should not be suffered to rock themselves by wind, so as to form holes round their stems, but be well earthed up, or otherwise supported.

Trees and shrubs should be constantly freed from suckers and dangling shoots, and wall-trees ought to be regularly kept in order. Grass plats and walks should have their edges occasionally cut, and be mowed as often as there is the least hold for the scythe, for they lose much of their beauty when the grass gets long; leaves should not be suffered to remain on them, as it stains the grass, and worm-casts should be cleared away. Edgings of all sorts should be kept in good order, as having a singularly neat effect in the appearance of a garden.

Some fruits may need support by tying their weak branches when they get heavy, to stakes, &c. Rows of raspberries and beans are kept neatly up in their lines, by putting in here and there a stake, and using packthread lengthwise; and thus will they bear better, and be more conveniently gathered. Strawberries of fine heavy sorts, will be preserved from getting dirty and rotten by tying their stems to little sticks; by this practice, the fruit also gets better ripened, and of a finer flavour. Some persons lay tiles or moss round the plants when the fruit is half-grown; but this is not, generally, so well, only it has the advantage in keeping the ground cooler in a hot season. The first and finest scarlets best deserve this trouble.

Flowers should be frequently tied up, and dead and dangling parts trimmed off. Some of them cannot do without support, and many sorts are made more secure and beautiful by proper ties. The sticks used for flowers should be of smooth wood, as neat painted slips of deal, with or without an ornamental head; white is the best colour, on account of its contrast with the leaves. Decaying flowers should be timely trimmed or removed, and perennials should be regularly freed from the parts running to seed, (except so much as may be wanted,) as the production of seeds weakens the roots much.

Of Propagations.—Plants are propagated by seeds, suckers, slips, off-sets, divisions, cuttings, layers, and grafts. By seed, is the most general method of propagation, and plants raised any other way are seldom so fine. Those plants from seed which have never been removed, are commonly handsomer, and some forwarder, than those that have been transplanted, provided they are sown in a proper soil and situation. Commonly speaking, new seed is to be preferred to old, as growing the more luxuriantly, and coming up the surer and quicker. If old seed is knowingly sown, some allowance, in point of time, must be made. Pease and beans of two years old are, by some, preferred to new, as not running so much to straw. As to the age of seeds at which they may be sown and germinate, it is uncertain, and depends very much how they are preserved.

Seeds should be saved from fine forward plants, secured from rocking about when they get tall; guard them against birds, gather them regularly as they ripen, lest they are shed and lost, and keep them dry. Curious flower seeds are kept well in phials; others may be put into small drawers, and some hung up, or laid on shelves, in their pods. Seeds may be forwarded for sowing by various ways of promoting a germination before they are put into the ground. Broad and kidney beans may be put into soft water about 24 hours, to forward their growth, and to ascertain their vitality. The smaller seeds, as carrots, &c. may be prepared for sowing, by simply mixing them in a little moist sand, or fine earth, taking care that they do not lie longer than the usual time of their beginning to sprout. The season for committing seeds to the ground should be as early as the nature of the plant to be cultivated will bear. Let this direction for early sowing be understood, not only of spring, but autumn crops; that the plants designed for winter use, or to stand for spring, may be strong, and well established in the ground, though for those designed for spring, it is advisable to have two or three different sowings.

To be sure of a crop, and in some things a succession of crops, various sowings should be made through the year at all times, that are not too unnatural as to season; for it is an object in gardening, not only to have early and late productions, but never to be without what may be produced. Sowings should be generally performed on fresh dug or stirred ground. The digging should, therefore, be done as near the time designed to sow as can be. If the ground turns up raw or wet, as early in the spring it is apt to do, a little time must be allowed it to dry, and so also if rain falls first. In this case, seed should be sown as soon as ever the ground may be trampled on without hanging to the feet. The proper depth at which seeds should be sown, is to be carefully observed; if too deep, they will either rot or not thrive well; and if too shallow, they are liable to be injuriously affected by frost, wind, drought, or birds; but of the two, rather too shallow than too deep is the best. The smaller the seed the finer should the soil be, and the less also the covering; so that while some, as the seed of celery, is to be but barely covered; others, as pease and beans, may have a depth of two, three, or four inches. But some regard is to be had to the season and soil; in a warm season, and light soil, sow deeper, and the contrary in shallower.

The quantity of seed sown is a thing to be attended to with some exactness. Small seeds go a great way, and require a careful hand to distribute them; for though sowing a little too much is a trifle as to the value of seeds, yet to have them come up crowded thick is an evil.

It is not generally advisable to sow several sorts of seed on the same spot, as some persons are accustomed to do. Some little things of this sort indeed may be done, as a piece of ground newly planted with horse-radish, may be top-cropped with radishes or spinach, &c. A thin crop of onions upon new asparagus beds, may also take place, drawing them while young from about the plants. All seeds come up best when moderately pressed with the earth; for if they lie too lightly in contact with it, cold and drought more easily affect them; and when once seeds begin to germinate, they are impatient of both. To trample seeds is, on the whole, better than any other pressure. This done, lay all immediately and neatly level with a wide rake, drawing off stones, &c. but do it lightly, to avoid driving in the teeth of the rake, which would remove the seed, and make it come up irregularly.

Propagation by suckers, is a mode of culture peculiar to trees and shrubs. The things to be observed in this business are, to take them up with some care from the mother plant, so as not to injure its root, nor the sucker's own root, by pulling it up without properly loosening it first. The earth should be moved aside with a trowel, and then the sucker cut off with a knife. Wherever a root appears barked, the part below should be cut off. If it is desired to succeed well, in propagating by suckers, consider that all young roots are tender; let them be trimmed to form, and planted immediately. Suckers with poor roots must have their heads reduced the more. Propagation by slips, is of two sorts, either from the root or stem; and several sorts of flowers and herbs are increased this way. When from the roots, if the whole is not taken up, move the earth carefully aside, and slip off by a pressure of the thumb and finger, and be cautious of hurting the fibres of the slips, planting with good mould about them. Take off slips from the stem carefully by the push of the thumb, and not too many from the same plant, as it is apt to injure the place by tearing off some of the wood.

Offset, is a term sometimes applied to slips from fibrous roots; but more properly so from bulbous roots, which put forth many offsets. These are slipped away at the time they are taken up for removal or replanting, and commonly take two or three years before they bear flowers; dispose of them, therefore, in a nursery, where they may remain undisturbed till they come to a flowering state. Division of the roots, is a way of propagating many sorts of plants. To this end, of course they must be taken up, and then either carefully pulled, or cut asunder with a sharp instrument, as the case may require. It is not safe, however, to divide such roots into very small pieces. The general season for thus splitting fibrous-rooted plants is October, but it may be done early in the spring, as February.

Cuttings, of a variety of woody plants, will grow, and many trees and shrubs are propagated this way; but their sap must be of a watery nature, as those plants that are gummy will not strike, (or rarely,) though ever so much care is bestowed or time allowed them. The texture of the wood cuttings must be somewhat soft, as hard-wooded ones will not grow. The season for setting slips and cuttings is for some plants summer, as wall-flowers and myrtles; and for most, from October to March; but in general, the sooner the better. It has, however, been said, that spring is the best time for all, and that the sap should be in motion first. Cuttings should be well-ripened wood, and have the earth pressed to them the whole length they are in the ground, *i.e.* from four to six inches. Cut them with a sharp knife slopewise, and plant in a good soil, so situated as to have only the morning sun, and keep them cold (not wet) by occasional watering in dry weather.

Laying of branches, is a mode of propagation that may be adopted for almost all forest trees, and several sorts of fruit trees and shrubs, *i.e.* all that will grow from cuttings, and many that will not. Layers are made of the lower branches of the plant, which must be young and pliable, to bend down without breaking, to the depth of four, five, or six inches, in the ground, as the soil is light or heavy, at which they must be held securely by good pegs. Let the ground about layers be kept cool by occasional waterings, and laying some moss, turf, litter, or rather small pebbles, about them, which will not harbour insects. The part out of the ground may be supported erectly by a tie to a stick. It is a good way to slit with a sharp knife the part at the peg, as in carnation layers, a little more than an inch; and some prick a few holes about the part, at a joint, with a blunt awl, to help the layer to strike root. Generally, layers should be shortened to six or eight inches above the ground, or do it to two eyes, be it more or less above ground. Where there are no branches low enough to be brought into the ground, and it is not thought good to head down for the production of low shoots or suckers, plants may be layered by fixing a broken pot or a box, with a slit in the side, to the height necessary to lay in a branch. A branch also, if long enough, may be thrust through a hole of a garden pot upwards, then filled with earth, and supported by some contrivance, and shaded by some means, and in both cases water frequently the buds drawn through the hole of the pot. By this contrivance, rooted plants being procured in pots, may be turned out with the earth about their roots undisturbed. A branch of a vine thus layered in November, may be next year cut off, when the fruit is ripe, brought in a pot to table, and afterwards planted out. For propagation of fruit trees by grafting, see that article. —*Watkin's Cyclopædia.*

GARLAND, a sort of net, whose opening is extended by a wooden hoop, of sufficient size to admit a bowl or platter within it; it is accordingly used by sailors as a locker or cupboard, to contain their provisions, being hung up to the beams within the birth, where they commonly mess between decks.

Shot GARLAND, a piece of timber nailed horizontally along the ship's side from one gun-port to another, and fitted with several hemispherical cavities, to contain the round-shot ready for charging the great guns in battle.

GARLIC, the root of the Allium. This root has been subjected to chemical analysis; and is found to consist of albumen, mucilage, fibrous matter, and water.

GARNET, a sort of tackle fixed to the main-stay of a merchant ship, and used to hoist the cargo in and out at the time of lading and delivering her.

GARNET, in Mineralogy, is a species of the flint genus, of which there are two sub-species, *viz.* the precious, and common. The precious, or oriental, is red, but of various shades. It occurs most commonly crystallized, either as a dodecadron, or as a double eight-sided pyramid. Garnets are found in almost every country where primitive rocks exist. Switzerland and Bohemia are the two countries in Europe which furnish them in the greatest abundance. The impure garnets are used to advantage as a flux when they are found near the iron-mines, as they not only facilitate the fusion of that metal, but add something to the mass by contributing a portion of iron.

GARNISH, in Law books, signifies to warn.

GARNISHEE, used for the third person or party in whose hands money is attached within the liberties of the city of London, so called because he has had garnishment or warning not to pay the money, but to appear and answer to the plaintiff's creditor's suit.

GARNISHMENT, is a warning given to a person for his appearance, for the better furnishing of the cause and court.

GARRISON, in the art of war, a body of forces disposed in a fortress, to defend it against the enemy, or to keep the inhabitants in subjection; in the latter case, the garrison should always be stronger than the townsmen. Garrison, or winter quarters, signify a place where a number of forces are laid up in the winter season, without keeping the regular guard.

GARRISON *Guns*, such as are mounted and used in a garrison, consisting of the following weights, *viz.* the 42, 31, 24, 18, 12, 9, and 6 pounders, being made either of brass or iron.

GARTER, ORDER OF THE, a military order of knighthood, instituted by King Edward III. It consists of 26 knights companions, generally princes and peers, whereof the king of England is the sovereign or chief. The college of the order is in the castle of Windsor, with the chapel of St. George, and the Chapter-house, erected by the founder for that purpose. The habit and ensign of the order are a garter, mantle, cap, george, and collar. The garter, mantle, and cap, were assigned the knights companions by the founder, and the george and collar by Henry VIII. The garter is worn on the left leg between the knee and calf, and is enamelled with this motto, *honi soit qui mal y pense*, *i.e.* "shame to him that evil thinks hereof."

GAS, in Chemistry, a word that signifies a permanent elastic aëriform fluid. Gases are transparent, elastic, weighty, and in most cases invisible; they cannot be condensed into a solid state by any degree of cold hitherto known.

The air or atmosphere consists of a mixture of several gases, which may be obtained separately. The gases which we shall describe are,—

1. Atmospheric Air.
2. Oxygen Gas.
3. Nitrogen Gas.
4. Hydrogen Gas.
5. Carbonic Acid Gas.
6. Light Carbonated Hydrogen Gas.
7. Heavy Carbonated Hydrogen Gas.
8. Gaseous Oxide of Carbon.
9. Sulphuretted Hydrogen Gas.
10. Phosphuretted Hydrogen Gas.
11. Nitrous Gas.
12. Nitrous Oxide Gas.
13. Ammoniacal Gas.
14. Sulphurous Acid Gas.
15. Hydrochloric Gas.
16. Chlorine Gas.
17. Fluoric Acid Gas.

Atmospheric Air.—The mechanical properties of atmospheric air, such as its weight, elasticity, &c. are considered under the articles AIR PUMP and PNEUMATICS. Chemistry examines all its other properties. The air of our atmosphere consists of two elastic, aëriform bodies, called oxygen and nitrogen gases, possessing different properties; oxygen gas is capable of supporting combustion and animal life; nitrogen gas is destructive to animals, and extinguishes fire. The atmosphere contains carbonic acid; for alkalies become effervescent when exposed to it, and lime-water acquires a pellicle, or thin skin on its surface, on being exposed a sufficient time to the action of the air, even upon the highest mountains. Water also in the state of vapour is always found in the atmosphere.

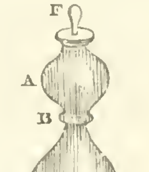
Oxygen Gas, is an elastic invisible fluid, having neither taste nor smell, nor shewing any signs of acidity; it is 740 times lighter than the same bulk of water. Its weight is to that of atmospheric air as 1103 to 1000. It is absorbed only by combustible bodies. It is necessary for respiration, and produces animal heat. It is considered the cause of acidity, and from this property is named oxygen, derived from two Greek words, denoting the cause of the acidity; these are *οξυς*, *acid*, and *γινομαι*, *to produce* or *generate*. Oxygen gas is procured in great purity from pure oxygenated muriate of potash. We have before described the method of obtaining this and other gases. It may likewise be obtained from the green leaves of plants, but not in sufficient quantity for chemical experiments.

Nitrogen or *Azotic Gas*, will not support life by respiration, but quickly kills animals that breathe it; plants, however, thrive, and even flourish in it. It has no taste. It neither reddens blue vegetable colours, nor precipitates lime-water. No combustible substance burns in nitrogen gas. It cannot be absorbed by water. It unites to hydrogen, under certain circumstances, and with it constitutes ammonia. When united to oxygen in different proportions, it forms atmospheric air, gaseous oxide of azote or nitrogen, nitrous gas, nitrous acid, and nitric acid. It is a component part of all animal substances; from which it may be obtained.

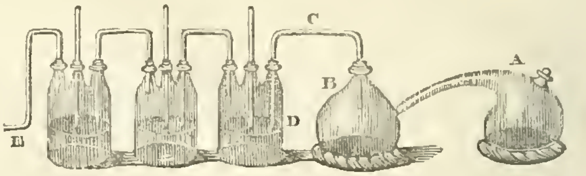
Hydrogen Gas, or inflammable air, is found in a natural state in muddy waters and in marshes, in mines, in coalpits, and in the bowels of animals. In these states, however, it is generally combined with carbon, sulphur, and phosphorus. It is exhaled from all places where there are animal or vegetable matters in a state of putrefaction. Hydrogen gas is obtained in a state of purity by decomposing water, because its base is one of the constituent parts of that fluid. This gas, therefore, has been called hydrogen, from two Greek words *υδορ water*, and *γινομαι*, *to generate*, that is, the generator of water.

Carbonic Acid Gas, (the first elastic aëriform fluid, different from common air, that was known,) cannot support flame, nor animal life; its taste is acid, and its specific weight is to that of atmospheric air, as 1·500 is to 1000. It may be poured from one vessel into another. This may be shewn by placing a lighted taper at the bottom of a vessel, and pouring carbonic acid gas over it from another vessel. The light will be immediately extinguished. Hence we infer, that the gravity of the gas has enabled it to descend, and to displace the common air at the bottom; which being lighter, is of course obliged to ascend. Carbonic acid gas is diffused in the greatest abundance throughout nature.

Marble, limestone, and chalk, consist of this acid and lime. Carbonated water, or, as it has been called, soda water, is merely water impregnated by carbonic acid. This agreeable draught is made in a series of vessels containing water and common chalk. Sulphuric acid is poured in, which unites with the lime, and at the same time the carbonic acid is expelled. This acid is absorbed by the water which is ready to receive it. The sparkling of carbonated waters is owing to the rapid escape of the gas. What is called *soda water*, or, more properly speaking, carbonated water, is made in an apparatus, of which the annexed is a figure. C is a flat vessel, having a cock D, through which chalk and sulphuric acid are supplied for forming the gas, which passes through the tube H, by a valve into the vessel B, containing the water to be saturated, and which may be drawn off by the cock E. Into this vessel is inserted a tube proceeding from another vessel A, also charged with water, and having an opening F, in which is placed a stopper, and through which fresh water is occasionally poured. The water in the upper vessel, and the weight of the stopper, press and agitate that in the vessel B, by which it is more speedily impregnated. The whole is made of glass, and is termed Nooth's apparatus.



For the general purposes of impregnating water with gases, a set of glass vessels (called Woulfe's apparatus) is used. Annexed is an engraving of this apparatus. A is a retort having a tubulure, through which the materials for procuring any gas are passed. B is a globe or receiver, into which is inserted a tube C, bent at right angles, and communicating with the second receiver D. From this one, another tube proceeds in the same way to the third receiver, and from the third another passes to the fourth. E is the last tube, which passes through water into any vessel, for the reception of the most volatile product, or that which will not combine with the water or other fluid contained in the three-necked bottles. It will be seen that a perpendicular tube enters the middle neck of each receiver. These are *safety tubes* to prevent the apparatus from bursting, as the gas might be evolved too quickly from the retort to be absorbed by the water. Sometimes these tubes are bent at right angles, and have a drop of mercury in them, which moving up and down, according as the gas is abundantly generated, acts as a valve, permitting the superabundant gas to escape. By means of this apparatus, water may be impregnated by muriatic acid and nitrous gases, so as to form muriatic and nitric acids. To shew that carbonic acid gas is fatal to animal life, put a mouse, or other small animal, into a vessel filled with it, and cover the vessel to prevent the admission of atmospheric air. The animal will die in a minute or two. It is this gas which has produced so many fatal accidents at the opening of cellars or vaults, in which wine, cider, or beer, has been fermenting.



Light Carbonated Hydrogen Gas, is hydrogen gas holding charcoal in solution. There are several kinds of it obtained by different processes, which differ in their properties, and in the proportions of their constituent principles. This gas is obtained from animal, vegetable, and mineral substances. Nature produces it in marshes and ditches, on the surface of putrid water, in coal mines, burying places, common sewers, and in those situations where putrid animal and vegetable matters are accumulated. It is also generated in the intestinal canal of living animals, and may be plentifully obtained from most stagnant waters. It may also be obtained during the distillation of animal and vegetable matters. This gas is known in coal mines by the name of fire-damp. Its destructive effects had probably been felt in all collieries until this moment, but for that useful invention of the immortal Davy—the safety lamp; or, as the miners in gratitude term it, "the Davy." This lamp is on the principle of the impossibility of the passage of inflamed gas through apertures of small diameters. Accordingly, wire-gauze is used for this purpose. *See* Lamp.

Heavy Carbonated Hydrogen Gas, was first noticed by some Dutch chemists, who observed in it a particular property, that when it was combined with oxygenated muriatic acid gas, the aëriform state of both fluids was destroyed, and oil was produced; for which reason they call it olefiant gas. This gas is obtained in decomposing spirits of wine by sulphuric acid in a great heat. It is also obtained abundantly, when alcohol is passed through a red-hot earthen tube. Sulphuric ether, mixed with sulphuric acid, and subjected to heat, also affords it.

Gaseous Oxide of Carbon, first described by Dr. Priestley, is exceedingly noxious; animals die in it instantly. It is obtained from chalk and filings of zinc.

Before closing these articles we may observe, that carbonic acid gas—the choke damp of mines—escapes also during the fermentation of porter; and instances of its destructive effects have occurred, where persons have incautiously put their noses to the bung-holes of casks while this process was going on. Charcoal fumes, so deleterious in many manufactories, are generated by burning charcoal in common air, and are in fact nothing more than *carbonic acid gas fumes.* A pan of lime-water placed on the floor will absorb the gas, and allow the artizan to respire tolerably pure atmospheric air. Yet, strange as it may appear, carbonic acid gas is evolved from our lungs in respiration, as is proved by breathing into a phial containing pure lime-water, which will become quite turbid by the combination of the pure lime with the carbonic acid proceeding from the lungs.

Sulphuretted Hydrogen Gas, has the properties of an acid; for when absorbed by water, its solution reddens vegetable blues. It combines also with alkalies, earths, and with several metallic oxides. This gas has an odour resembling that of putrid eggs. It kills animals, and extinguishes burning bodies. It is inflammable when mixed with oxygen gas, or atmospheric air. It is this gas which gives their peculiar smell to the waters of Harrowgate, Aix-la-Chapelle, and St. Bernard's Well at Edinburgh.

Phosphuretted Hydrogen Gas, consists of phosphorus dissolved in hydrogen gas. It is the most combustible substance in nature, and is distinguished from all other gases by taking fire when brought in contact with atmospheric air. When mixed with oxygen gas, or with oxygenated muriatic acid gas, it burns violently. When bubbles of it are suffered to pass through water, they take fire in succession as they reach the surface of the fluid. Its smell resembles that of putrid fish. Phosphoretted hydrogen gas is also found naturally. The air which burns at the surface of certain springs, forming what are called burning springs, and the *ignis fatuus* (jack o'lantern,) which glides along burying grounds, consists of this gas.

Nitrous Gas, is an aëriform fluid, consisting of a certain quantity of nitrogen gas and oxygen. It is colourless, having no sensible taste, and is neither acid nor alkaline; it cannot be respired. The greater number of combustible bodies cannot burn in it. It is, nevertheless, capable of supporting the combustion of some bodies. Phosphorus burns in it when introduced in a state of inflammation. Homberg's pyrophorus takes fire in it spontaneously. It is obtained from copper and nitric acid diluted with water.

Gaseous Oxide of Azote, or nitrous oxide, obtained from the nitrate of ammonia, by heating the salt to about 400° Fahrenheit, is a permanent gas, in which animals, when confined, give no signs of uneasiness at first, but soon become restless, and then die. When mingled with atmospheric air, and then received into the lungs, it generates highly pleasurable sensations. It excites the body to action, and rouses the faculties of the mind, inducing a state of great exhilaration, and an irresistible propensity to laughter, a rapid flow of vivid ideas, and unusual vigour and fitness for muscular exertions; in some respects resembling the sensations attendant on intoxication, without any languor, depression of spirits, or disagreeable feelings afterwards, but more generally followed by vigour, and a disposition to exertion, which gradually subsides.

Ammoniacal Gas, is composed of hydrogen and nitrogen, rendered gaseous by the addition of caloric. This gas suffocates animals, and extinguishes burning bodies, like all the other suffocating gases; but it is slightly inflammable, increasing the flame of a taper before it extinguishes it.

Sulphurous Acid Gas, is no where found in a natural state, but is entirely a production of art, obtained by exposing to heat in a retort, sulphuric acid, while it is exercising an action on some combustible body, as oil, charcoal, mercury, &c. Sulphurous acid gas is twice as heavy as atmospheric air. It extinguishes burning bodies, and suffocates animals. It first reddens, and then destroys, most of the vegetable colours. It has the property of whitening silk, and giving it a lustre.

Hydrochloric or *Muriatic Acid Gas,* obtained by exposing to heat, fuming muriatic or hydrochloric acid, put into a retort, the beak of which is introduced below a bell-glass filled with mercury, and placed on the shelf of a mercurial pneumatic apparatus, is heavier than atmospheric air, suffocates animals, and extinguishes a lighted taper; but first enlarges its flame, and makes it appear of a green or bluish colour at the edges.

Chlorine or *Oxygenated Muriatic Acid Gas,* the muriatic gas deprived of its hydrogen, is of a greenish yellow colour. This gas destroys vegetable colours only, rendering all flowers, and the green leaves of plants, white; and alkali is not capable of restoring their colours. Hence this acid is now very generally employed in the gaseous or the liquid state, to whiten thread, cotton, linen, wax, &c.

The oxygenated muriatic acid is employed in four different ways for the purpose of bleaching; first, in the state of gas alone; secondly, in the state of gas combined with water, or what is called the acid; thirdly, potass is mixed with the acid to condense the gaseous vapour, and destroy its suffocating odour; fourthly, oxygenated muriates, dissolved in water, are employed. *See* the article BLEACHING, pp. 108—111.

Fluoric Acid Gas, may be obtained by decomposing fluate of lime (Derbyshire spar) by means of sulphuric acid. The most remarkable property of this gas is its power of dissolving silex; it therefore dissolves glass, crystal, and various precious stones. It is heavier than common air. It does not maintain combustion, nor can animals breathe it; but its property in dissolving flint makes it useful in etching on glass, either as a gas, or in a liquid state.

There are a variety of other gases, the enumeration of which in this place would be attended with little utility to the reader of a work like our Dictionary.

On the Expansion of Gases; with an easy Rule, and a Table, for finding the Expansion of Air or any Gas, from 32° *to* 212° *Fahrenheit.*—An accurate knowledge of the expansion of gaseous bodies being of great importance in chemical researches, many experiments were made to ascertain it, but the results were long so various and different from each other, that none could be depended on. The reason of this difference was the want of attention on the part of experimenters, in not excluding with sufficient care the particles of water from the vessels employed to measure the expansion of gases. When, therefore, heat was applied to raise the temperature of any gas, the particles of water were converted into vapour, and mixing with the gas, produced a difference in the actual change of bulk which it had experienced. To this cause only can be ascribed the variations in the determinations of Deluc, General Roy, and others, on this important point. The subject happened to engage the attention of Dalton, of Manchester, and Gay Lussac, in France; and the coincidence in the results of their experiments affords convincing proof of their accuracy. Dalton published the account of his experiments about six months before Lussac, and his apparatus was more simple than that of the French chemist. It consisted merely of a glass tube, open at one end, and graduated into equal parts; after it was properly dried, the gas was introduced into it, and it was then filled with mercury at the open end to a given point; heat being then applied, the amount of dilatation was observed, by the quantity of mercury expelled. Lussac's apparatus was more complicated, but capable of greater precision; and, as his experiments were made in greater quantities of air, their coincidence with the former induced perfect confidence in the accuracy of the results.

Their experiments led to the important conclusion, that air, and all gaseous bodies, undergo the same degree of expansion, by the application of the same degree of heat; so that the rate of expansion for one being determined, gives the rate of expansion for all. The expansion obtained by Gay Lussac, by heating air from 32° to 212°, was ·375, or ⅜ of its bulk at 32°, and that obtained by Dalton, was ·376 for the same bulk. Now, this fact being established, that air expands about ⅜, or one-2·666th of its bulk, when heated from 32° to 212°, or 180°; it follows, that for every 1° of the thermometer, air will expand one-four hundred and eightieth part of its bulk at 32°. The experiments of Dalton would give about one-479·8th for this expansion, but the difference is of no great moment. From the experiments of Lussac, it appears, that the steam of water, and the vapour of ether, experience the same expansion as air, when the same addition is made to their temperature; hence it may be inferred, that all elastic fluids expand equally and uniformly by heat.

To determine, therefore, the expansion of air, or any gas, at any temperature, or in other words, to ascertain the increase of bulk which it undergoes, when heated from the commencement of the common thermic unit 32°, to any degree within its range, which terminates at 212°, we have only to add one-480th part of its bulk, at 32° for every degree between that point and the temperature required.

Thus, if the bulk of a quantity of any gas at 32°, be 10 cubic inches, and its bulk at 60° be required, we have only to subtract 32° from 60°, and the remainder 28 is the number of degrees intervening; then $\frac{1}{480} \times 28 = \frac{28}{480}$ the expansion of a unit for 28°; wherefore, $\frac{28}{480} \times 10$ cubic inches $= \frac{280}{480} = \cdot5833$, the increase of volume, which, added to 10 cubic inches, makes 10·5833 cubic inches, the bulk of the gas at 32°, when raised to the temperature of 60°. If the bulk of a quantity of gas, at any temperature above 32° be given, and its bulk at a still higher temperature be required, we must first subtract 32° from the given temperature; then add the remainder to the denominator of the fraction $\frac{1}{480}$, and proceed as before. Thus, to find the expansion of 10 cubic inches of gas at 50°, when raised to the temperature of 60°, we have 50° − 32° = 18°, and 60° − 50° = 10°. Now, $\frac{1}{480 + 18} = \frac{1}{498}$, and $\frac{1}{498} \times 10° = \frac{10}{498}$, the expansion of a unit for 10°, wherefore $\frac{10}{498} \times 10$ cubic inches $= \frac{100}{498} = \cdot208$, the increase of volume, which, added to 10 cubic inches, the bulk of the gas at 50°, when raised to the temperature of 63°.

If the bulk of a quantity of gas at a higher temperature be given, and its bulk at a lower temperature be required, we must then subtract 32° from each temperature, and add the remainders to the denominator of the fraction $\frac{1}{480}$; then making the least sum the numerator, and the greatest the denominator of a new fraction, we proceed with the operation as before. Thus, to find the contraction of 10 cubic inches of gas at 80°, when cooled to the temperature of 60°, we have 60° − 32° = 28°; and 80° − 30° = 40°; also, 80° − 60° = 20°; hence, $\frac{480 + 28}{480 + 48} = \frac{508}{528}$, the expansion of a unit for 20°; wherefore, $\frac{508}{528} \times 10$ cubic inches $= \frac{5080}{528} = 9\cdot4318$ cubic inches, the volume of the gas at 80°, when cooled down to the temperature of 60°.

Such is the mode of calculation adopted by chemists, in the calculation of the expansion of air and gas, and the examples might be so varied as to give occasion for a variation in the rules for each; but we proceed to give a much more simple and general rule for determining this expansion in every case that can be proposed within the thermic unit.

Rule.—The volumes of all the gases are to each other as 448 + *the temperature;* that is, *as* 448 + *the given temperature, is to* 448 + *the required temperature, so is the bulk of a quantity of gas at the given temperature, to its bulk at the required temperature.* Thus, in the first of the above cases, we shall have 448 + 32° : 448 + 60° : : 10 cubic inches : 10·5833 cubic inches, or 480 : 508 : : 10 cubic inches : 10·5833 cubic inches, the bulk of the gas at 32°, when raised to the temperature of 60°. as found above.

In the second case, we shall have 448 + 50° : 448 + 60° : : 10 cubic inches : 10·2008 cubic inches, or 498 : 508 : : 10 cubic inches : 10·2008 cubic inches, the bulk of the gas at 50°, when raised to the temperature of 60°, as found above.

In the third case, we shall have 448 + 80° : 448 + 60° : : 10 cubic inches : 9·4318 cubic inches, or 528 : 508 : : 10 cubic inches : 9·4318 cubic inches, the bulk of the gas at 80° when cooled down to the temperature of 60°.

From these examples will be seen the superiority of this single rule, to the former methods of calculating the increase or diminution of the volumes of gases, when expanded by heat, or contracted by cold.

The following Table, constructed on these principles, shews the expansion of air for nearly every temperature, from 32° to 212°, supposing that its bulk at 32° is unity 1·000000, or 1000000

TABLE.

Temp.	Bulk.	Temp.	Bulk	Temp.	Bulk.
32°	1000000	59°	1056219	86°	1112499
33	1002083	60	1058333	87	1114583
34	1004166	61	1060416	88	1116666
35	1006349	62	1062499	89	1118749
36	1008333	63	1061583	90	1120833
37	1010416	64	1066666	91	1122916
38	1012499	65	1068749	92	1124999
39	1014583	66	1070833	93	1127083
40	1016666	67	1072916	94	1129166
41	1018749	68	1074999	95	1131249
42	1020833	69	1077083	96	1133333
43	1022916	70	1079166	97	1135416
44	1024759	71	1081249	98	1137499
45	1027083	72	1083333	99	1139583
46	1029166	73	1085416	100	1141666
47	1031249	74	1087499	110	1162199
48	1033333	75	1089333	120	1183333
49	1035416	76	1091666	130	1204166
50	1037499	77	1093749	140	1224999
51	1039583	78	1095833	150	1245833
52	1041666	79	1097916	160	1266666
53	1043749	80	1099999	170	1287499
54	1045833	81	1102083	180	1308333
55	1047916	82	1104166	190	1329166
56	1049999	83	1106249	200	1349999
57	1052083	84	1108333	210	1378823
58	1054166	85	1110416	212	1375000

TABLE *shewing the Absolute Weights and Specific Gravity of Gases, and the Quantity of each absorbed by Water.*—Temperature 60° Fahrenheit. Barometer 29·8.

KIND OF GAS.	Weight of 100 cubic inches, in grains.	Specific Gravity.	
		Water the standard at 1000.	Air the standard.
Nitric acid..................	76·	3·	2425
Sulphurous, ...	70·215	2·75	2240
Vapour of ether, ...	62·1	....	2250
Muriatic acid, ...	59·8	....	1929
Vapour of alcohol, ...	51·5	....	2100
Nitrous oxyde, ...	50·1	1·985	1615
Carbonic acid,...............	46 5	1·81	1500
Ditto, ditto, ...	45·5	1·802	1170
Muriatic acid, ...	44·7	1·765	1430
Sulphuretted hydrogen, ...	48·17	....	1231
Nitric oxyde,................	37·	1·465	1193
Nitric oxyde,................	31·3	1·36	1105
Oxygen gas, ...	34·74	1·39	1127
Sulphuretted hydrogen, ...	34·286	1·36	1142
Oxygen gas,.................	34·	1·35	1103
Atmospheric air, ...	31·	1·2279	1000
Azotic gas,..................	30·535	1·21	985
Azotic gas, ...	30·45	1·20	980
Carbonic oxyde, ...	30·	1·185	967
Olefiant gas, ...	28·18	....	905
Hydrocarburet from stagnant water, ...	20·66	....	660
Ditto from coal, ...	20·2	....	650
Ditto from ether, ...	20·	....	645
Ammonia, ...	18·16	0·715	585
Ditto, ...	18·	0·713	580
Arsenicated hydrogen gas, ...	....	0·6499	529
Hydrocarburet from alcohol,..	16·	....	516
Ditto, from water over ignited charcoal,...................	14·5	....	468
Hydrogen gas, ...	2·613	0·1031	84
Phosphuretted hydrogen, ...	....	....	....

Gas *Light.* Having, under the article Coal, explained the method of obtaining this artificial light, we now proceed to describe and illustrate the apparatus of a manufactory of Gas for public use, from a treatise on Gas Lighting by Mr. Peckston, in which theory and practice are happily combined. On this subject Mr. P. is preparing a larger work, which, if we may judge from the ability and science displayed in what is now before us, will be found of intrinsic value.

Gas is obtained from distilling coal in a retort—it is then purified—and, finally, let off to the consumers by means of *pipes.* The consideration of the two processes of distillation and purification solicit our chief attention; the process of distribution shall be briefly discussed, when the former steps shall have been fully explained.

The retorts used for the distillation of pit-coal, are of different shapes in different establishments, being in some *circular,* in others *elliptical, square,* or *semicircular.* There have also been invented *rotatory retorts.*

The circular retorts (for, in adverting to the shape of them, I am to be understood as speaking of that section which is vertical and parallel to the flanches at their mouths) are cylinders of about six feet in length, and twelve inches diameter inside. These have, till recently, been set on the flue plan, and when set two to one fire, carbonization was carried on at about twenty per cent.; or, to speak in more familiar language, it required twenty chaldrons of coals to keep a sufficient number of retorts so heated as to be capable of carbonizing one hundred chaldrons in a proper manner; when the retorts were worked at eight hours' charges, with two bushels of coals to one retort each charge. The fire-place for heating this kind of retort was opposite to its mouth; and under these circumstances, a retort, cast from metal of the second running, and weighing about ten hundred weight, would last from eight to ten months.

The first step towards the present mode of setting retorts was, by heating three with one fire; on such plan several were set in different works. Retorts set three to one fire having, by experiment on a large scale, been proved to answer no desirable end, the next alteration in the mode of setting was, that of heating four by one fire. On this plan, a hundred retorts were put up at one of the establishments in London—these it was found impossible to heat; for one part of the retort would have actually melted before the other had arisen even to a dull red. A second setting of retorts, in which four were to be heated by one fire, succeeded better than the first, for the retorts heated very regularly—but carbonization was not carried on at so low a per centage as when only two were heated by one fire; it was considerably increased, and what was still worse, the retorts were sooner burnt out. The carbonization increased daily in its expenses, till at last it rose as high as fifty per cent. This was owing principally to working fewer retorts than the fires necessary to be kept up would have heated, had the retorts placed over each fire in action remained in a working state; for it very frequently happened, when seventy or eighty retorts were working, as many fires were kept lighted as actually heated a hundred, and for the following reason:—The action of the fire not being uniformly directed towards each retort in the series of four, one of them became ineffective; when such was the case, only three out of the four could, of course, be used; soon afterwards a second failed, and then but two remained in use, and so on;—indeed, it was no uncommon circumstance to work but two retorts by that fire which actually heated four, owing to two of them being burnt out. When retorts were set four to one fire, it happened that they were frequently worked under the above disadvantage more from necessity than choice; for whenever it became necessary to remove defective ones over one fire, it followed that the adjoining fires could not be kept lighted; for if they remained so, the bricklayers could not perform their work—consequently, when it was required to replace a series of four, the use of twelve retorts was lost to the manufacturer till such time as the defective ones over the fire-place undergoing repair, were again ready to be brought into action. The pulling down of the defective retorts, and the replacing of them so as to be again ready for charging, in one series, was seldom accomplished in less than a week; therefore, when the manufacturer was unable, from the quantity of gas he had to supply, to dispense with the use of so many retorts, he was compelled to work them under every disadvantage.

As the expense of resetting one retort, when put up in a series of four, for labour and new materials, exclusive of the retort itself, amounted to about eight pounds, or at the rate of thirty-two pounds for each series, it became a *desideratum* to be able to replace a burnt-out retort without pulling down the brickwork and allowing the retorts next adjoining to remain inactive. Actuated by a zeal for promoting the interest of the manufacturer, my attention was turned to the subject; and, after very maturely considering the matter, Mr. Peckston hit upon a plan which would enable the operator to remove a defective retort in a few hours, without expense, save labour, and a few shillings for bolts and cement.

When retorts were set four to one fire, the top ones invariably failed first, and this led to a supposition that if the top ones were guarded by tiles from the action of the fire in the same way that the lower retorts were guarded, they would be more likely to remain a longer time effective. Retorts were accordingly so set, and whilst the fire-places were continued at that side which was opposite to the side for charging and drawing, they did last considerably longer, but then they were by no means so effective as on the former plan. They fell out of all shape, and consequently were not capable of carbonizing such a quantity of coals as would be advantageous to the manufacturer of coal gas. A deviation from this mode was made by placing the fires in front of the retorts, but it failed entirely. The bottom retorts were soon destroyed—the action of the flame playing on the ends of them so forcibly as literally to reduce them into a state of fusion, when the fire was such as to keep the principal part of the retort at a bright red heat.

Although retorts of various shapes had been tried at different establishments, we find no account of any having been set, save on the flue plan, that is, by the fire acting under the retort, and then returning over it on its way to the main flue, till the spring of 1817, when Mr. Rackhouse adopted a plan for heating retorts of cylindrical shape set in ovens, a plan since known to the manufacturer by the name of the "oven-plan." His first experiment was made at one of the gas-light establishments in London, by heating one retort in an oven. He next set two in one oven, then three, and afterwards five; and cylindrical retorts set in fives on the oven-plan are now by far the most general mode adopted at the different gas-light establishments.

Mr. Malam's plan of oven retorts at the Westminster gas-works, perhaps, excels the former. Various have been the alterations made by different workmen in the fire-work to the retorts since the oven plan was adopted, but hitherto most have failed in remedying the very serious evils which must arise from their rapid destruction. Heretofore a retort of the same shape and dimensions, when constantly used night and day, lasted from eight to ten months; but, on the oven plan, the retort seldom remains in a working state more than as many weeks. Indeed, so great has been the desire of making this plan answer, that it has been tried almost under every bearing; and whilst some attempts have promised to answer, others from which much had been expected have failed so far as to cause the retort to be entirely destroyed in three or four days.

Whenever coal may be submitted to distillation in masses of twelve inches diameter, the operation will be very tedious, and equally imperfect; the action of the red-hot retort upon the outer surface of the coal will soon decompose it, and therefore the gas in the first part of the process will pass over very rapidly—but then it acts against the process in the interior part of the cylinder formed by the coal in the inside of the retort; for as the outer surface of the coal is formed into coke, it becomes a coating to that which is within it, and through which the gas must pass ere it can extricate itself from the retort. Whenever such is the case, carbonization cannot be carried on to advantage, nor will it ever answer the most desirable end. The great object which the manufacturer should ever keep in view, is by exposing coal to the action of heat in thin strata, to obtain the greatest quantity of gas in the least time, and at the least expense, but such can never be effected by retorts like these.

Having thus glanced cursorily at the various modes which have been adopted for setting cylindrical retorts, it may not be improper to notice the rotatory retorts of Mr. Clegg's invention. In doing so, we are to observe that Mr. Maiben, of Perth, invented a retort for distilling coal by exposing it to the action of heat in thin strata. From his experience he learnt that the gas evolved during the first part of the process of carbonization was of too aqueous a quality to be fit for combustion, and that evolved during the latter part thereof was so strongly impregnated with sulphur as to be highly objectionable. The retorts he made use of were of a square shape, and of a size sufficient to carbonize twenty-five pounds of coal, when spread in a layer of about two inches deep. The coal was introduced into the retort by means of a sheet-iron box, which was charged and slided in whenever the gas was extracted from the former charge, which, under such management, was generally accomplished in two hours. But this description of retort being much too small to be serviceable in large establishments, led Mr. Clegg to construct a retort of sufficient capacity for carbonizing about one chaldron of coals *per diem*. The first of them which was ever put up, (being eight feet six inches in diameter,) as were also the second and third, (each of twelve feet six inches diameter,) were worked under my observation. Each of these retorts contained fifteen boxes which slided into the retort, upon iron arms, as described in the specification of the patent. Whilst the arms could be kept up, they were worked without much difficulty. The coal remained in the retort six hours, but was only one-third of that time exposed to the action of a red heat. Five boxes, having passed that, waited for the coal in the five boxes over the red heat being decomposed, which, on being done, the retort was opened, and those five boxes which had passed the red heat, were drawn, and fresh ones introduced upon the arms they had occupied, which process brought the five from the red heat to the situation they had occupied, to wait there till the coal in the next five was decomposed, when the operation of change was again repeated; so that there were continually five boxes lately introduced into the retort, waiting to be brought over the red heat, five over the red heat, and five others ready for being withdrawn from the retort. Had not the expense of erecting retorts of this description been very considerable, and the wear and tear enormous, they would doubtless have been adopted in that establishment where they were first tried; but both were so much against them, that every idea of using them was there entirely relinquished. It is but justice to state, that those retorts produced gas at the rate of upwards of fifteen thousand cubic feet per chaldron (twenty-seven hundred weight) of coals; that carbonization was carried on at about sixteen or eighteen per cent.; that the increase of coke on coal, carbonized, was at the rate of fifty per cent.; and, that the process of carbonizing, under those circumstances, was accomplished in about six hours.

Mr. Maiben's retorts were much too small for extensive manufactories; the rotatory one so very expensive, that it was not probable either would be brought into general use. To overcome the difficulties arising from the use of retorts, Mr. Malam proposed that elliptical retorts should be adopted, their length being about six feet six inches, their transverse diameter twenty inches, and their conjugate diameter ten inches. From retorts of such shape there was every probability that the results, as far as related to the quantity of gas and coke obtained from a chaldron of coals, would be very similar to those from the rotatory retort; whilst the expense of setting them was but little more than would have been incurred by setting an equal number of cylindrical retorts, and not near so much as it would require to set such number as would carbonize equal quantities of coals in equal times. The elliptical retorts had, however, one great advantage over the cylindrical ones,—they were worked off in half the time; and five of them in action, worked with one bushel and a half of coals to each, during a few hours' charge, would produce as much gas in a day as ten cylindrical retorts worked at eight hours' charges, with two bushels to each retort every charge. The elliptical retorts on which my observations were made, were set in an oven and heated by one fire.

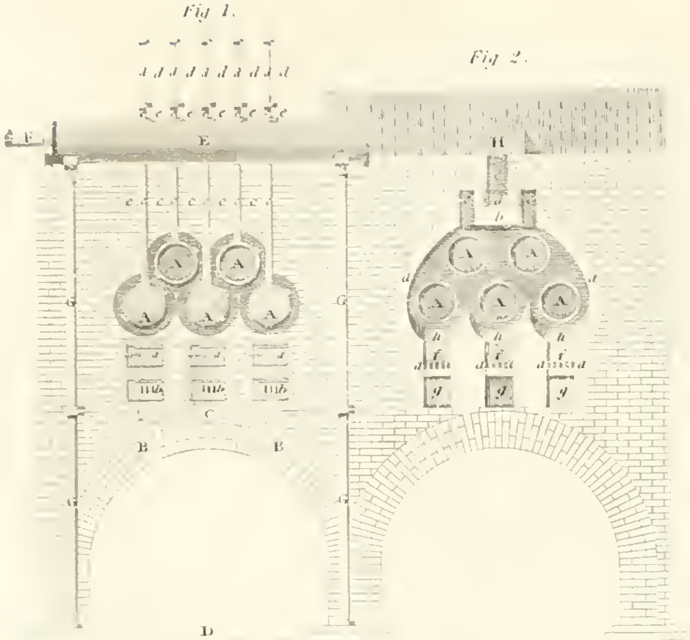
The semicircular retort, from its form, is likely to answer the manufacturer's purpose, if set with judgment, next to the rotatory and elliptical ones; that is, as far as the generation of gas and the production of coke are concerned; but, from its shape, its durability cannot be expected to be equal to the latter. The action of the fire upon the lower edges will very soon destroy it; for, it must be obvious, to any one at all acquainted with fire-work, how very powerfully the flame strikes upon any angular points. This, in the elliptical retort, is, of course, done away with, whilst the advantage arising from its shape is retained.

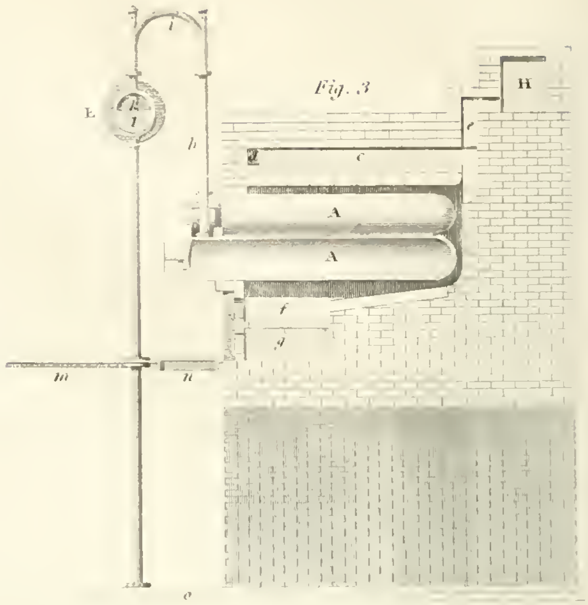
The square, or parallelopipedal retort, is twenty inches in breadth, thirteen inches high, and six feet long, inside. It has a rib cast along the middle, on the inside of that part which is, when set, the bottom. This rib rises to the height of three inches, but does not approach nearer to the mouth-piece than about eighteen inches. It is for the purpose of strengthening the bottom of the retort, and preventing it from falling out of shape; but, when we consider the mode in which square retorts are set, it will not appear to be necessary. These retorts, when set six in one bed, and that number heated by one fire, are placed close alongside each other. The fire-place, being at one end of the range, is so contrived as to admit of the flue being carried under the whole range towards their mouths; it is then brought over the top of them, and again under and over in the like way, previous to its being allowed to enter into the main flue. Under this arrangement, square retorts, weighing about thirteen hundred weight, being set and worked at six hours' charges, with one bushel and a half of coals to each as one charge, at such a heat as causes ten thousand cubic feet of gas to be generated from a chaldron of Bewicke and Craster's Wallsend coal (twenty-seven hundred weight), are found to remain serviceable one year. The carbonization is, when they are once brought to a working state, carried on at about twenty-five per cent.; but they require to be fired for a fortnight or three weeks before they are at a proper temperature for carrying on that process.

The disadvantages which attend the use of those retorts are, first, that they are more expensive in the first instance than cylindrical ones: secondly, the length of the flue passing under and over them being extensive, and of but small dimensions, it frequently becomes choked up, and requires, for clearing it out, various openings. When, therefore, it is found necessary to examine those flues, it generally happens that the heat of the retorts is very considerably decreased; and when we consider the time requisite for heating them in the first instance, we must be aware that such a diminution cannot be overcome but by a considerable expense of fuel, and carrying on the process very unfavourably and imperfectly. Lastly, when the retort is burnt out, the cost of replacing it is nearly equal to the first cost of setting; whilst, in using cylindrical ones, a retort is generally replaced for about three-fifths of its first cost.

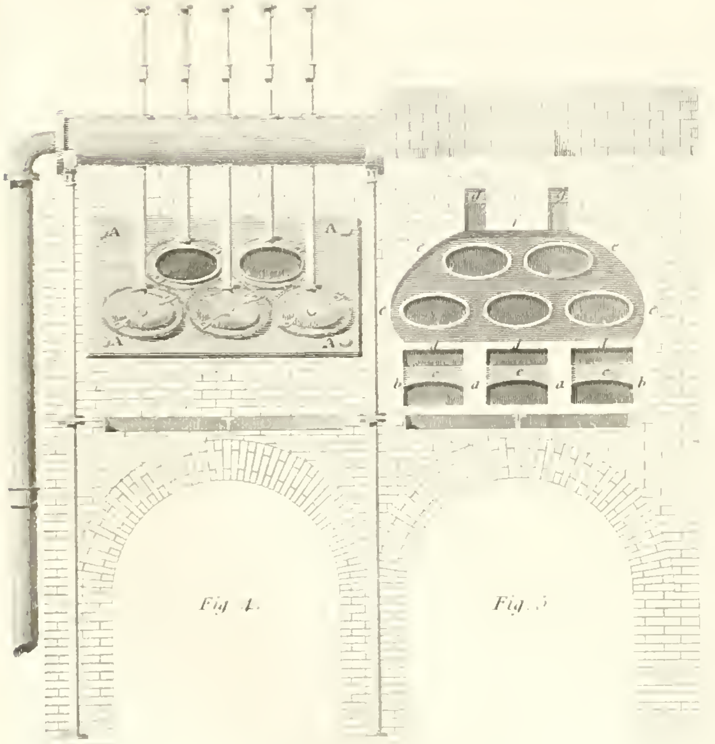
On the 5th of August, 1817, a patent was obtained by John Perks, for an arrangement such as to cause thirteen retorts, each capable of carbonizing a bushel and a half of coals in six hours, to be heated by one fire. The retorts are so placed, that, when the observer stands in front of them, twelve of the number form a circle round the thirteenth, which is cylindrical, the centre thereof occupying the position of the common centre of the surrounding ones. The shape of these retorts will be best understood by supposing two circles struck from the centre of the mouth-piece of the thirteenth retort; the inner one forming one side of the series of twelve, and the outer one the other. If, then, either of these circles be divided into twelve equal parts, and lines drawn from the inner to the outer circle, radiating from their common centre, the transverse vertical section of them will be exhibited. It is evident, that, under this arrangement, they form a complete circle of large diameter. The mouth-pieces are formed like those which are used with the square retorts, and, of course, the conducting pipes and pipes leading to the hydraulic main, are nearly similar to those used for either cylindrical or square retorts. The fire-place is in front of these retorts, and as they are all enclosed in a circle of brick-work, which is divided into four equal parts by fire lumps laid horizontally, and so brought out of the circle as to be in contact with the adjoining retort; and that part which is

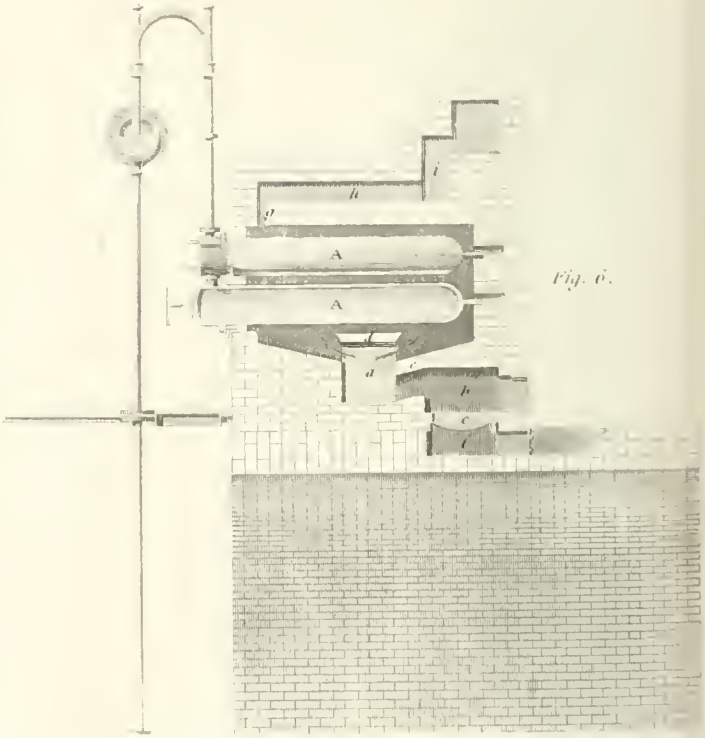
GAS LIGHT RETORTS FOR DISTILLING PIT COAL.





Section of the method of setting five cylindrical Retorts in one oven, heated by three Fires, at the Station of the [illegible] Gas Light [illegible]





Sections of the method of setting elliptical Retorts, now successfully used at the Chartered Gas Light & Coke Company's Establishment, Peter Street, Westminster.

between the central retort and the others, being divided in a similar way, the action of the fire is under three, and then, turning over their ends, it comes over them towards their mouths, where it finds an opening leading above the next three; and, passing their ends downwards, it is brought towards the mouths a second time, and so on in like manner, till it has traversed round the whole series, when it passes into the main flue.

Description of the Method of setting two cylindrical Retorts on the Flue plan, so as to be heated by one Fire.—Fig. 1, represents a front view of two retorts set to one fire on the flue plan. In it, the manner in which the conducting pipes are connected to the retorts is exhibited: these lead to the hydraulic main.

Fig. 1.

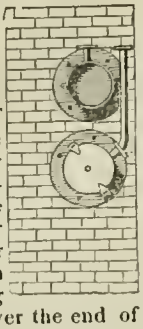


Fig. 2.

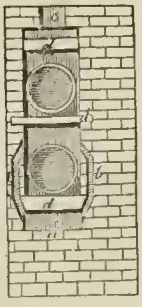


Fig. 2, is a vertical section of the same retorts, supposed to be drawn about midway of their lengths. In this section *a* represents the end of that part of the flue leading from the fire under the lower retort, which rises near the mouth-piece thereof through the openings *b b*, and, passing between the two retorts, rises over the end of the upper one; and, being brought over the top of it, by means of an opening *c*, about nine inches from the mouth-piece, enters the upper flue, and thence passes into the main one. *d d d* are end sections of the fire-tiles; on the two lower lines of them the retorts are supported, and the upper one forms the base of the top flue.

Fig. 3.

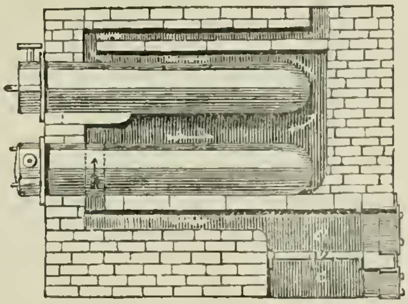


Fig. 3, exhibits a longitudinal section of these retorts. In it, *a* is the fire-place, *b* a section of the fire-bars, and *c* the ash-pit. The direction taken by the flue is pointed out by small arrows.

Description of the Method of setting six parallelopipedal Retorts, so as to be heated by one Fire.—Fig. 1, represents a transverse section of parallelopipedal retorts, in which six are heated by one fire. These retorts are twelve inches square inside, and six feet in length. The fire-place *a* with the ash-pit *b* is placed t one end of the series, but so as when the observer stands in front of the retorts he shall be in front of the fire-place also. Under this arrangement, the retorts 1 and 6 heat the best, and 5 the worst. If the reader compares the situation of the flues, as exhibited in fig. 2, he will observe that there are four which communicate with the fire-place. These are divided by lumps laid edgewise across the whole series of retorts, forming the flues marked *d d d d*, fig. 2. This range of flues is covered by fire-tiles, and upon them the retorts are placed close alongside of each other. Over the top of the retort is a range of flues *c e e c*, which corresponds with the lower ones, and these are covered with fire-tiles and of course with fire-bricks. Upon the latter is a third series of flues of about two-thirds the depth of the former ones, and these rise by the opening *f*, fig. 2, into the main flue. In fig. 1, the transverse direction of the flues is shewn by the arrows leading from the fire-place. The mouth-pieces of these retorts are circular, as shewn upon retort 6, fig. 1, last column. Fig. 2 represents a longitudinal section of these retorts, in which the flues and action of the fire have already been described. A is the retort, *a* the fire-place, *b* the ash-pit, and *c* the fire-bars.

Fig. 1.

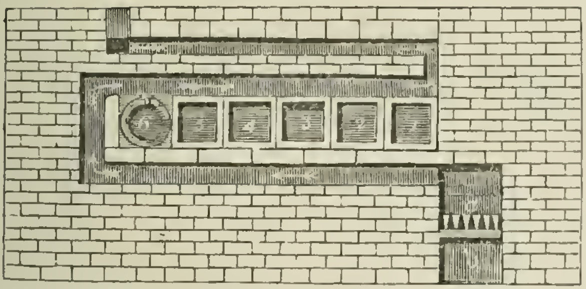
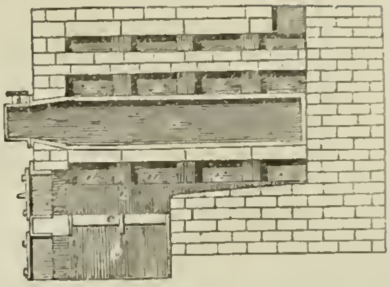


Fig. 2.



Description of the Method of setting five cylindrical Retorts in one Oven heated by three Fires, with Sections of the hydraulic Main and Dip-Pipes, as exhibited in the Plate of GAS LIGHT RETORTS.—Fig. 1 represents a front view of the retorts A A A A A, as set and in a finished state. In it the two upper retorts are shewn without the lids of their respective mouth-pieces: the two outer lower ones with the lids on, but without their being secured by the cruss-piece shewn upon the middle one. The bed of these retorts is supported by an arch of brick-work, marked B B. It is brought so far forward as to allow room enough for the stokers to charge and draw the retorts, and for a sufficient quantity of coals to be kept for supplying two or three charges, with fuel for present use, luting, tools, &c. Immediately in front of the retorts is introduced, instead of part of the key-stone for the arch, a cast-iron frame of about three feet and a half long, and two feet broad at the top, with an iron door fitted to it. The bottom of the frame is struck to the radius of the arch, and of course the sides taper inwards in proportion to that radius. The situation of the opening is expressed at C. This opening is for the purpose of allowing the red-hot coke when drawn from the retort to fall into the archway at D. *a a a*, the doors of the fire-places, *b b b* the doors of the ash-pits. These doors are furnished with three perpendicular slits of about two-thirds their length and five-eighths of an inch in diameter, for allowing a current of air to pass to the fires. The dimensions of these slits can be decreased by another piece, made with openings to correspond, which slides horizontally in grooves in a line with them, so as to regulate the admission of air to such a degree as the operator may desire. *c c c c c* are the conducting pipes which convey the gas as it is evolved from the retorts towards the hydraulic main. *d d d d d* front sections of the H pipes. *c c e e c*, front sections of the dip-pipes, with the saddles through which they are bolted to the hydraulic main. E the hydraulic main, F the main pipe for conveying the gaseous and other products evolved towards their respective reservoirs. G G G G cast-iron columns fitted with crutches at the tops of the upper ones for supporting the hydraulic main.

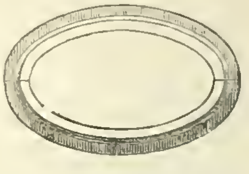
Fig. 2 is a section of the same retorts, which supposes them to be cut through from the top to the bottom about the middle. In this section, the hydraulic main, dip, and conducting pipes, are not shewn. A A A A A the retorts. *a a a a a a*, such part of the arch forming the oven and brick-work contiguous to the fire-places, all of which require to be constructed of Welsh fire and arch bricks. The crown of the oven is flattened by means of Welsh fire-tiles as at *b*. At the extreme end of the oven are two openings, which lead into the two small flues *c c*. These flues pass above the top of the oven towards the front of the retort, and then each turns towards the centre flue *d*, which having entered, that one leads towards the main flue H, which it enters through the opening *e*. *f f f* are the fire-places, and *g g g* the ash-pits. *h h h* are fire-lumps placed beneath the lowermost retorts, for protecting them from the action of the fire. The two upper retorts are supported near their middle by wrought-iron belts, which are brought through the upper part of the oven, and passing through a cast-iron bearing bar placed above it, are secured, by means of nuts, in the situation wanted. When the oven-plan was first introduced, the retorts were supported by cast-iron props bedded in the brick-work, crutch-shaped at the top, and rising to a proper height to receive them. They are not now used, and therefore not shewn in the plate.

Fig. 3, is a longitudinal section of cylindrical retorts set on the oven plan. A A are the retorts, the mouth-piece of the lower one being secured by the lid and cross piece; the upper one is shewn without the lid. *f* is the fire-place, with the position of the grate-bars. *g* is the ash-pit. The action of the fire is the same in this section as has been already described by fig. 2: the flame having exerted its force in the oven, rises by the opening shewn at the extreme end of the retorts, and passes along the flue towards their mouths till it comes to *d*, when it enters the middle flue lying parallel to the flue *c*; that leads into the rising part *e*, and thence into the main flue H. *h* is the conducting-pipe which conveys the gaseous and other products from the retorts to the H pipe *i*, and that carries them into the dip-pipe *k*, which enters into the hydraulic main E. In this section of the hydraulic main, the fluid by which the dip-pipe is sealed is shewn as at *l*, through which the gas bubbles up as it is evolved, and passes along the upper part of the hydraulic main towards the main pipe F (as shewn in fig. 1) on its way to the condenser. The hydraulic main is supported in this section in a similar way to what was shewn in fig. 1; but instead of a brick arch for supporting the floor in front, *m* is one of a range of beams for supporting a cast-iron floor. *n* is the opening for allowing the coke when drawn from the retorts to fall on the floor *o*. This opening is covered by an iron door, which is closed at all times, save when the retorts are drawing.

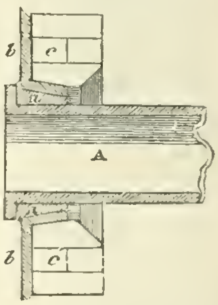
Description of Mr. John Malam's Method of setting Five of his Elliptical Retorts in one Oven heated by three Fires, with Sections of the Hydraulic Main and Dip-Pipe, as exhibited in the Plate of Gas Light Retorts, *Figs.* 4, 5, *and* 6.—Fig. 4 represents a front view of the retorts, as set and in a finished state. The arrangement of the retorts, hydraulic main, dip and H pipes, being nearly similar to that described above, a repetition of description is not necessary here: we shall, therefore, only describe such parts as differ from the former mode of setting. In front of these retorts is a cast-iron plate A A A A, against which the flanch of the retort rests. At each corner of this plate is a hole for receiving a bolt. This passes through the brick-work to the back of the retorts, which is supported by a plate of similar dimensions to that in front, cast with openings opposite the end of each of the retorts. These openings are secured by plugs, which are removed when it is requisite to replace a retort that may be worn out. In it are also openings for the sights. The bolts stated to pass through the front plate pass through this also, and both are secured together by screwing up their respective nuts. Under this arrangement, it is not necessary to disturb any of the brick-work, when, from a retort becoming ineffective, it requires replacing. The fires for heating these retorts are placed at their back.

Fig. 5, is a section of the same retorts, which supposes them to be cut through from the top to the bottom about the middle. *a a* are fire-lumps placed edgewise so as to divide the distance between the exterior lumps *b b* into three equal parts corresponding with the fire-places. *c c c* are the ends of the arches over the respective fire-places as they meet the dividing lumps *a a*. *d d d* are three fire-tiles resting upon the lumps *b a a b*; these tiles form a bridge from one side of the oven to the other. *e e f e e* is a section of the oven, the rising part on each side marked *e e* being constructed of Stourbridge arch bricks, and the flattened part *f* of Welsh lumps or fire-tiles. *g g* are sections of the two horizontal flues which rise near the mouth of the retort, and pass towards the main flue.

Fig. 6 is a longitudinal section of elliptical retorts set on Malam's plan. A A are the retorts. *b* is the fire-place. *c* is a section of the grate bar. The lower edge of this bar is chamfered off and of a circular form. It is of sufficient depth to allow the action of the cool air through the ash-pit to have full effect upon it, thus preventing the very rapid destruction which generally attends cast-iron grate bars. *f* is the ash-pit. *a* is a section of the lump for dividing the flames from the different fire-places. *d* is a section of the tiles which form the bridge. The flame acting under the arch *c*, as expressed in this and the former figure, passes between the dividing lumps under the range of tiles *d*, and there divides itself in the direction of the two arrows, by this means causing the heat to act uniformly in the oven. The opening flue is expressed at *g*—it passes along *h*, and rises at *i*, preparatory to entering the main flue. These retorts are cast with a cylindrical projecting end, which is received into the brick-work: they are also supported by cast-iron props (bedded in the brick-work beneath them) crutch-shaped at the top. The section of the hydraulic main, dip, and H pipe, as also of the floor, is the same as shewn in the section of cylindrical retorts set on the oven plan, page 365, to the description of which our readers are referred.



The annexed figure, is a transverse section of the couplings which surround the retort when it is set. The face of the couplings is brought close up to the flanch of the retort. In the following figure, *a a* is a longitudinal section of the couplings, they are wedge-shaped. A is a section of part of the retort. *b b* the iron plate in front of the oven, cast with flanches verging inwards so as to fit to the couplings when brought to their places by the flanch of the retort coming close to the plate. *c c* part of the brick-work in front of the oven, so angled off as to allow the heat to approach as near the mouth-piece as the couplings will permit. When this plan is adopted, it is evident that, by introducing the couplings nearly to their places, and bedding them in cement, the bringing of the retort to its situation in the oven will force them up, and form a complete joint round it. On the contrary, when a retort becomes defective by displacing the plug opposite to the end, and bringing a purchase upon that end by means of an iron bar, (the joint between the mouth-piece and gas conducting pipe being first broken) it will be forced out of the situation it had occupied, and loosen the couplings. When the retort has been moved about a foot, they may be taken away, thus leaving sufficient room for the retort to pass: it may be drawn out by a purchase made fast to an eye-bolt in the wall opposite thereto, and a new one introduced into its place, the whole operation being performed in two or three hours.



Mr. Peckston's Table, *exhibiting at one View the Advantages and Disadvantages which arise to the Manufacturer from the Use of different Kinds of Retorts variously worked.*

Reference to Description of Retort.	*Durability in Days.*	*Usual Charge in Bushels of 84 lbs. each.*	*Time allowed for working off one Charge.*	*Gas produced from one chaldron, the retort being worked at a bright red heat.*	*Per Centage at which Carbonization is carried on.*	*References to the Mode of setting the Retorts.*
				Cubic Feet		
A	270	2	8	10,000	20	*a*
A	180	1½	6	9,000	30	*a*
A	180	1¼	4	8 500	30	*a*
A	180	2	8	9,000	25	*b*
A	120	1½	6	8,500	33	*b*
A	120	1¼	4	8,500	35	*b*
A	180	2	8	10.000	25 to 50	*e*
A	120	1½	6	9,000	do.	*c*
A	120	1¼	4	8,500	do.	*c*
B	63	2	8	10,000	16 to 40	*d*
B	42	1¼	5	9,000	do.	*d*
C	270	1½	4	15,000	30	*e*
D	300	1½	6	10,000	25	*f*

In the first column of the foregoing table, from A is to be understood that the results expressed in a line with that letter arise from the use of cylindrical retorts of the dimensions, &c. as hereafter mentioned, that is to say,—Dimensions, 6¼ feet long, 1 foot diameter inside; weight, 10 cwt. 2 qrs.; price, per ton, £12; first cost of setting, including retorts, brick-work, labour, hydraulic main, and connexions, with coke hearth, complete, £23; cost of replacing one that may be worn out, £15.

Those marked B in the first column are of the same dimensions, price, and weight.

Those marked C are elliptical, and of the following dimensions, &c.:—Length 6½ feet; transverse diameter inside, 20 inches; conjugate diameter inside, 10 inches; weight, 13 cwt. 2 qrs.; price, per ton, £13; first cost of setting, including retorts, brick-work, labour, hydraulic main, and connexions, with coke hearth, complete, £25; cost of re-setting, when the oven in which they are placed requires to be rebuilt, £18.

Those marked D are parallelopipedal shaped, and of the following dimensions, &c.:—Length, 6 feet; breadth inside, 20 inches; depth inside, 13 inches; weight, cwt. 13; price, per ton, £12; first cost of setting, including retorts, brick-work, labour, hydraulic main, and connexions, with coke hearth, complete, £21; cost of re-setting, £18.

The letter *a* in the last column of the table, implies that the results opposite thereto are from retorts set on the flue plan, two being heated by one fire at the back of the retorts. The letter *b* in the same column,—retorts set on the flue plan, three being heated by one fire in front of them. The letter *c*,—retorts set on the flue plan, and four being heated by one fire at the side opposite to their mouths. The letter *d*,—retorts set on the oven plan, five being heated by three fires immediately beneath the front of them. The letter *e* implies that the retorts are elliptical and set on Malam's plan, five being heated by three fires at the back of them. The letter *f* relates to parallelopipedal retorts, twelve being set in one bed and heated by two fires; the flues passing under and over six retorts from each fire.

When cylindrical retorts are set two to one fire, so as to produce, when worked at a bright red heat, in the proportion of 10,000 cubic feet of gas to a chaldron; if the temperature be decreased, they will not produce much more than 8000 cubic feet to the chaldron; but their durability will be extended to twelve months; and such decrease of temperature under any of the arrangements exhibited in the foregoing Table, when working cylindrical retorts, will cause a proportionate decrease in the quantity of gas generated, and an increased durability to the distillatory vessel.

Whilst cylindrical retorts, worked at a low temperature, are producing but 8000 cubic feet of gas from a chaldron of coals in eight hours, the rotatory retorts would in six hours produce from 15 to 16,000 cubic feet of gas from the same quantity of coal; and the elliptical retort from 14 to 15,000 in four hours.

When cylindrical retorts are set on the flue plan, and four heated by one fire at the back, should they be fitted with Mr. Peckston's apparatus for removing a defective one, they would always work eight hours' charges of two bushels to each retort at 25 per cent., producing 10,000 cubic feet of gas to the chaldron; and, when worn out, might be replaced for about seven pounds each.

Carbonization.—Were it requisite to go into calculation upon the different modes of working the retorts, taking the results of experiments made at different times and under various circumstances as data, it might be most clearly proved how much in all cases the longer process excels the shorter. In order, in some measure, further to elucidate this point, to observe, that whenever pit coal is to be submitted to the process of distillation, the time for the process cannot be shortened to less than eight hours, unless we have the means of exposing the coal to the action of heat in thin strata,—say four inches; and when coal is so exposed in cylindrical retorts, that retort which, when worked at the eight hours' process, is capable of carbonizing two bushels of coal, would only carbonize about three-fifths of a bushel. The segment of a circle, whose altitude is four inches, and chord eleven inches and a quarter, bearing such proportion to the capacity of the retort, the diameter of which is about twelve inches. We are told by those who have the management of carbonizing in different manufactories, that when the six hours' process is adopted, the charge is from a bushel and a quarter to a bushel and a half. In such case, the mass of coal is by no means sufficiently diminished so as to cause the process to be performed with advantage. When the retort is so charged and worked, the heat verging from all directions towards the centre, will meet with nearly the same obstacles to prevent the extrication of the gas, as if it had been fully charged.

With respect to these shorter charges when worked off by cylindrical retorts set on the oven plan, the same arguments which have been already advanced will hold good in favour of the eight hours' process, but with considerably more weight, inasmuch as the wear and tear of the retort will be proportionably greater. We may, therefore, from what has been said, draw this conclusion, namely, that whenever cylindrical retorts are used, let the mode of setting be what it may, the operator ought never to work off his charge in less than eight hours, and that with such heat as would produce from one chaldron of Newcastle coal (twenty-seven hundred weight) the average quantity of ten thousand cubic feet of gas.

When semicircular or elliptical retorts are used, either will admit of the charge being worked off in much less time than can be effected with cylindrical ones. For, in using the first, it would be advisable to introduce the coal into the retorts by means of sheet-iron trays nearly of their length and breadth, and about four or five inches deep. By having two sets of trays for the retorts in action, the time usually lost in charging would be greatly decreased, as would also the stoker's labour. By the mode most generally practised, the raking the ignited coke out of the retort is not only very laborious, but also attended with much loss of time,—both which would be avoided by the mode suggested; for by using the trays, the spare ones might be charged with the proper quantity of coal preparatory to the time for drawing, and by that means almost the only time occupied in the operation would be that required for breaking the joints of the mouth-pieces, and making them good again.

Carbonization, when carried on by means of semicircular retorts, if properly set, has a decided preference over cylindrical ones;—for, as the great art of making gas to advantage, depends upon exposing coal to the action of heat in thin strata, such kind of retorts are particularly adapted to the purpose. They have, however, one disadvantage, which has not passed unnoticed. The action of the flame upon the angles at their base, tends towards destroying them with considerable rapidity. To guard against such destruction, the angular part has been rounded off so as to present an arc of a circle to the fire, instead of an acute angle, and such alteration was doubtless for the better. Were such retorts set on the plan of an air-furnace, in which every part of them could be regularly heated, without directing the heat more forcibly against one particular part than another, they could hardly fail of answering a very desirable end to the manufacturer of coal-gas. From the numerous experiments made on the distillatory process, on the plan of submitting the coal thereto in thin strata, it can hardly be doubted but retorts of this description, if set with judgment, would remain serviceable from six to eight months, being charged every four hours, night and day, with two bushels of coal each, and worked at such heat as to produce from a chaldron of coals the average quantity of thirteen thousand cubic feet of gas, with an increase of coke, (particularly adapted for parlour fires, as well as culinary purposes,) of 40 per cent. upon the quantity of coal carbonized; consequently, that five retorts of this description would produce as much gas during the space of twenty-four hours as would require twelve cylindrical retorts to be worked at eight hours' charges with two bushels of coals to every charge, or sixteen cylindrical retorts worked the same time with a bushel and a half of coals to each retort for one charge.

As what has been said on the subject of carbonization when carried on by means of semicircular retorts, is in almost all respects applicable thereto when square retorts are used, it therefore will not be necessary to take up the reader's time by speaking of it here.

The next mode of carrying on the process of carbonization is by means of elliptical retorts, for which purpose it would be difficult to find a better. The elliptical retort combines in it the durability of the cylindrical one, with the advantages obtained by exposing the coal thinly to the action of heat upon a large surface, and therefore, when it is used, the process will be accomplished in about four hours. Upon retorts of this description I have had opportunities of making observations, the result of which leads me to pronounce such well adapted for promoting the interests of the manufacturer. Five elliptical retorts are capable of carbonizing forty-five bushels of coal *per diem*, and of generating from that quantity of coal about seventeen thousand cubic feet of gas, or at the rate of fourteen thousand cubic feet per chaldron. From one chaldron of coal, when elliptical retorts are used, will be produced a chaldron and a half of saleable coke. The elliptical retorts on which my observations were made, were set five to one fire, and so well was the heat disposed of, that from one end to the other they remained, whilst in action, at a bright cherry redness; being kept so night and day for more than ninety days, they were not much injured,—from their appearance, there could be little doubt but they would remain serviceable nearly twelve months. They were charged and drawn in the usual way; but notwithstanding the charging and drawing was more frequent, the stokers found it more easy to work them than a like number of cylindrical retorts. Their shape allowed room to rake out the coke more rapidly than could be done from those of a cylindrical form, and the coke not being so compact when produced in the elliptical retort, required considerably less labour to clear it from thence. It would be no exaggeration to state the results arising from the use of these retorts, to bear similar proportions of advantage over the cylindrical ones, to those stated when speaking above of semicircular-shaped retorts.

The annual expense of cylindrical retorts, when worked at eight hours' charges, together with the wear and tear of grate-bars, is stated to be £2360, when worked to produce 44,598,684 cubic feet of gas. When elliptical retorts are used, one retort will remain in a sound working state about twelve months; if, therefore, we calculate the expense of elliptical retorts, with their appendages, for one year, and compare the various results together, we shall find how far they are advantageous:—

By using elliptical retorts, worked at the four-hours' process, it would require about forty retorts to be kept constantly at work to produce 857,667 cubic feet of gas per week,—such retorts so worked would remain serviceable twelve months, consequently there would be but forty burnt out in a year,—the cost of replacing each being £18, amounts to £720 0 0
Wear and tear of grate-bars, ... 60 0 0

£780 0 0

Expense of cylindrical retorts, &c. for one year, when worked at the eight-hours' process, so as to obtain 44,598,684 cubic feet of gas, is £2360 0 0
Elliptical retorts as above, ... 780 0 0

Balance in favour of the elliptical retorts, ... £1580 0 0

Annual balance in favour of working elliptical retorts as above described, over cylindrical ones at eight hours' charges, as far as relates to coals, products, and labour, ...£1135 1 3½
Ditto, as far as relates to the wear and tear of retorts, grate-bars, &c....................... 1580 0 0

The sum.........................£2715 1 3½
is the total annual balance.

The annual balance in favour of working cylindrical retorts at eight hours' charges over charges of six hours, when required to generate by either, 44,598,664 cubic feet of gas in a year, was stated to be £5511 16 10
Therefore, if to this we add the balance as above in favour of elliptical retorts,........ 2715 8 3½

we have.................£8226 18 1½
saved in one year by using elliptical retorts, in preference to carbonizing with cylindrical ones, let them be set as they may, if worked at six-hours' charges, with a bushel and a half of coals to each as an average charge.

Hydraulic Mains and Dip Pipes.—By the term "Hydraulic Main," as used in the gas-light establishments, is understood that cast-iron pipe which is supported by columns in front of the brick work enclosing the retorts. It is so situated, as to lie parallel to the top of that brick work, at a distance of from twenty inches to two feet from it. Its use is to receive the "Dip Pipes," through which the gas, as it is evolved from the retort, passes, together with the other products, on its way to the condensing main, or to the vessel employed for condensation, as the case may be. The diameter of the hydraulic main is various in different establishments; in some it is ten inches, in others twelve or fourteen. In works where not more than from forty to sixty cylindrical retorts, six feet and a half long, and one in diameter, are set in one retort-house, a diameter of twelve inches will be sufficient. It is generally constructed of flanch pipes, in lengths of nine feet each. One end of it is closed by a blank flanch so as to be perfectly air-tight, the other has a semiflanch placed across it, of sufficient height to prevent the liquid introduced into the main from sinking below a certain level;—it is of advantage, that similar semiflanches be placed between every length of pipe forming the hydraulic main. These flanches should rise two inches and a half above the line of the bottom of the dip-pipes; by such means, the gas, as it is discharged from the retort, will always have to pass through such depth of fluid, before it can enter into the hydraulic main.

The use of the hydraulic main, as has been already stated, being for receiving the dip-pipes, we are to consider what end they may be intended to answer.

A section of the hydraulic main, with the most approved dip-pipe, is given in the Plate, fig. 2. The dip-pipe is about two feet in length, and three inches diameter inside; at the top is a socket for receiving another pipe of the same diameter. At about eight inches from the spicket-end of the dip-pipe is a circular saddle of about nine inches diameter, cast to the radius of the exterior surface of the hydraulic main. This main being tapped for the reception of such a number of dip-pipes as there are retorts to work into it, they are jointed upon it by means of iron cement in the usual way; when that is done, it is evident that the range of the spicket-end of these pipes will equally descend, and of course, supposing the hydraulic main to be placed perfectly level, which it always ought to be, should one of them be immersed two inches and a half in any liquid that it may contain, each one of the range will be so.

Now, when it is considered, that if there were not some contrivance for preventing the gas returning from the main pipes towards the retorts, when the mouth-pieces are removed in the operation of drawing, either by stop-cocks on each of the "gas conductors," or other means, the process would not only be very wasteful, but extremely hazardous; for, as the gas would be passing over by means of the conducting pipes to the hydraulic main, in a range of sixty retorts, from fifty-two of them, whilst eight were drawing, it would follow that the whole quantity of gas then generating would escape at the mouths of the retorts that had their lids taken off, and burst forth with such a flame as no one could come near; if not attended with still more serious consequences by the admission of atmospheric air, which might cause the most violent explosion.

The necessity of means being adopted for preventing such things happening, is obvious; and a more simple, and at the same time safe, method than that of the hydraulic main and dip-pipes could hardly have been thought of; for, had stop-cocks been used, they would have been attended with considerable trouble, and always liable to get out of order, so much so, that no dependence could be placed upon them; for the tar and ammoniacal salts would, in a few days, so clog the plugs as to render them immoveable. If the pressure upon the hydraulic main from the purifying vessel be greater than the distance between the bend of the H pipe and the spicket-end of the dip-pipe, in the hydraulic main, the gas, after having once entered that main, cannot be forced back to the retort.

By the pressure from the purifying vessel, is to be understood, the depth of lime in solution through which the gas, after entering it, has to rise through before it can escape to the gas-holder, the most usual depth of the purifying mixture through which the gas bubbles up in purification being ten

Gas Light Condensers Purifiers &c. Pl. 2

Fig 3 Palmers Purifier

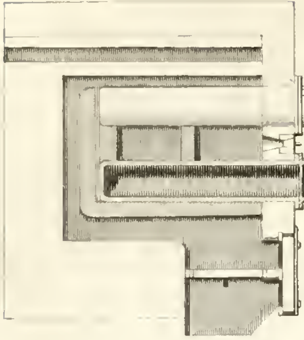
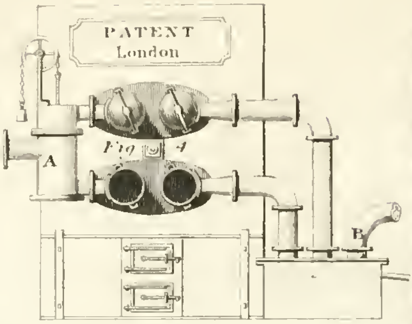


Fig 5.



Perk's Condenser

Fig. 1.

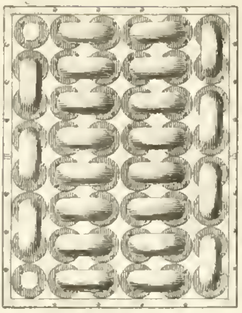


Fig 2

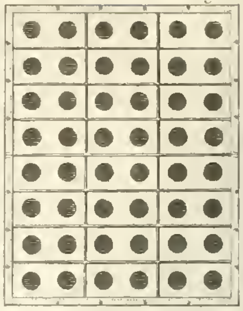


Fig 2 Hydraulic Main

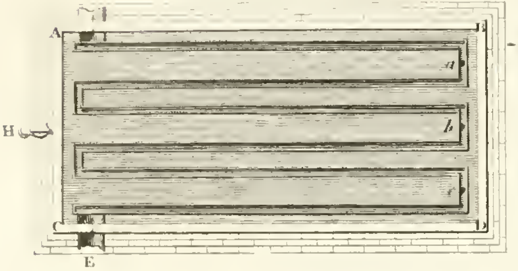


Fig 3

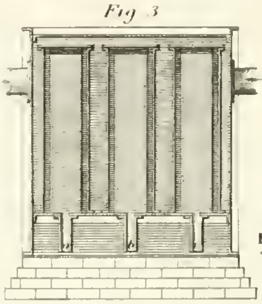


Fig 1 Malam's Condenser

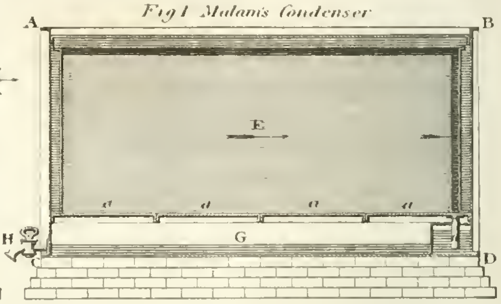


Fig 1

Cylindrical Gas Holder

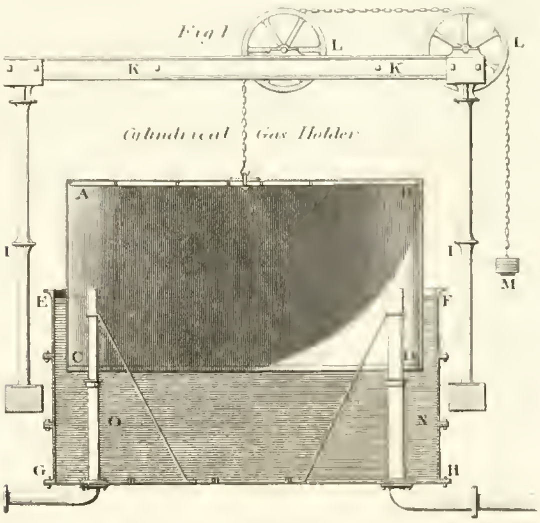
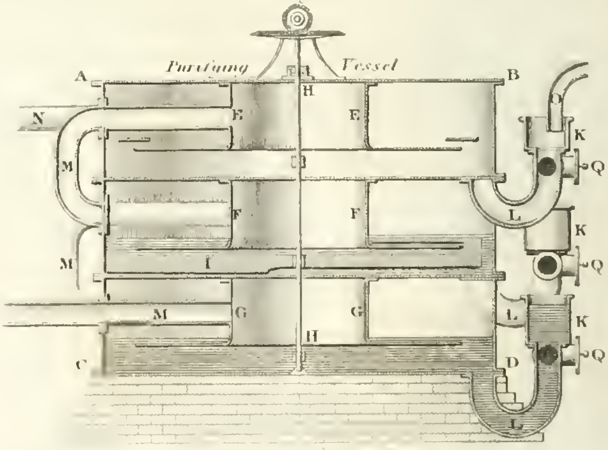


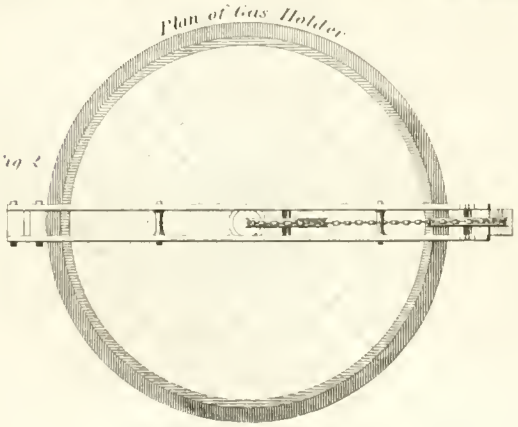
Fig 1

Purifying Vessel



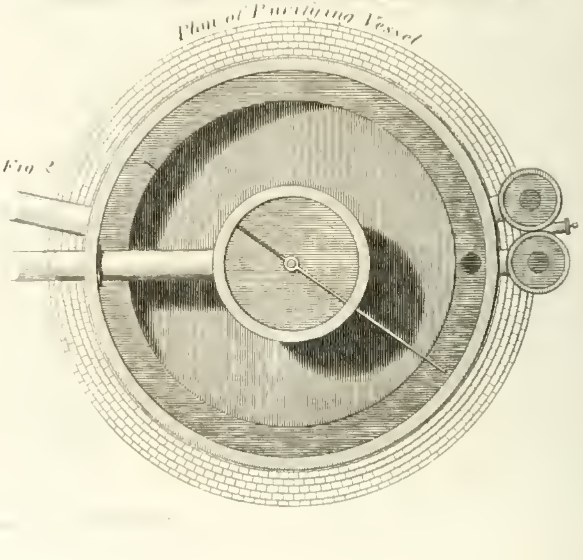
Plan of Gas Holder

Fig 2



Plan of Purifying Vessel

Fig 2



inches, the purifying vessel is said to be worked at ten inches' pressure. The length of the dip-pipe is two feet; from the top of it to the centre of the bend part of the H pipe, about six or eight inches more, making altogether about two feet and a half; consequently, before the pressure in the lime vessel can be of sufficient power to force back the gas from the hydraulic main through the conducting pipes to the retorts undergoing the operation of drawing, it would require to be three times greater than what the vessel is usually worked at.

The main, of which we speak, with the dip-pipes, form a series of hydraulic joints, than which, in the manufacture of so elastic a fluid as coal-gas, nothing could be so well adapted,—nothing could be so safe.

Accidents have been heard of, occasioned by the gas in the hydraulic main exploding, and forcing the glans from the top of the pipes perpendicular thereto, (usually called the H pipe, from its similarity to that Roman letter,) but such accidents must have arisen from great carelessness on the part of the operator, or from the clogging up of the purifying vessel.

The condensing Main, and various Methods of Condensation.—The gas, when evolved, being mixed with tar and ammoniacal fluid, in a state of vapour, which pass over with it from the retort to the hydraulic main, it becomes necessary, that, *as much as possible*, these two products should be condensed and lodged in the proper receptacle before the gas reaches the purifying vessel. In order that this condensation may be properly effected, the products generated should be exposed to a large surface of some cold body on their passage to the purifier; by this means the tar and ammoniacal liquor are separated in a great measure from the gas, and, being of so much greater density, fall to the bottom of the pipes, and drain from thence to the vessels appropriated for their reception. The gas is also cooled, and made much more fit for the lime to act upon than if it were brought directly from the hydraulic main to the lime vessel in a hot state; for, whenever it is so, it is impregnated with the tar and oleaginous particles, which very soon render the purifying mixture useless. The consequence following is, that a much greater portion of lime will be required for the purifying process, or otherwise that the gas will pass through the lime vessel into the gas-holder, without being acted upon. The use of impure gas ought, on all occasions, to be avoided, for whenever it is used, it is almost impossible to obtain a good light; when it is submitted to combustion it is smoky, and emits a disagreeable odour; the plugs of the stop-cocks on the fittings in houses become choked up with tar, which, however surprising the case may be, has been found in situations at a mile and a half distant from the manufactory, after having passed through various pipes of different sizes and at different levels.

Experience having taught the manufacturer the necessity of attending to the subject of condensation, he, of course, adopted such means as he considered most advisable for accomplishing it. In some manufactories it was thought that the gas would be sufficiently condensed, from its being conveyed from the hydraulic main by a pipe laid in a direct line from the retort-house to the purifier—in others, the gas was conveyed to the lime-vessel through a worm-pipe placed in the tank of the gas-holder—and again, in others, by a range of pipes laid parallel to each other at a considerable depth, and with a certain declivity from one end of the works to the other;—whilst some, in addition to these contrivances, proposed a tank, into which the range of pipes, as last specified, should convey the gas at the bottom, and by means of a contrivance something similar to the shower-bath, have it washed there before it could make its exit towards the purifier. Most, if not all, of these modes, have been tried by different operators, and have been found more or less effective.

Malam's condenser is also a square cast-iron vessel, about nine feet long, five wide, and four deep. Into this vessel are introduced plates at the distance of from six to eight inches from each other, with raised edges of about three inches in height; these are bolted to the sides of the vessel, and are perfectly parallel to each other; they are in length about eight feet six inches, so that being secured to the sides of the vessel and one end of it, the other end will be at the distance of about six inches from that end of the vessel to which it is contiguous. The lowermost of these plates being connected to one end of the vessel, the next plate above it will be connected at the end opposite thereto—the third plate the same as the first—the fourth as the second, and so on alternately till all the plates are fixed. This being done preparatory to bringing the condensing vessel into action, water is introduced at the top, which filling the uppermost shelf to the height which the projecting part of it allows, it runs over and fills the second, from thence the third is filled, and so on till the whole range is so. From considering this matter, it is evident, that if the entrance pipe be at the bottom of the vessel to the right, should gas be introduced there by means of it, it will pass over a sheet of water equal to the area of the lower shelf, and as the next shelf above approaches no nearer than six inches to the end towards the left, it will by that opening rise above it and pass towards the right, where it will find an opening from the third shelf, and so it will pass alternately to right and left till it reaches the exit-pipe placed at the top of the vessel. The condensible products are carried from the respective shelves by means of small bends projecting from one end of this vessel; but as I am of opinion it will be likely to answer the purpose of the manufacturer both as relates to its first cost, durability, and action, I shall describe a condensing vessel of this kind, capable of performing what is required, where about 100,000 cubic feet of gas are generated daily.

The condenser we have just described, has undergone several alterations; we therefore shall proceed to describe Malam's improved condensing vessel, as exhibited in the Plate. A B C D, fig. 1, is a longitudinal section of this condenser. The vessel is a parallelopipedon made of cast-iron plates, supported upon a bed of brickwork. At about one foot from the bottom is a range of plates, *a a a a*, together of the same dimensions therewith, which are jointed to the side of the vessel. Upon these stand a row of plates of the same material, one of which is shewn, as at E. Their bases occupy such situation as is expressed in the plan A B C D, fig. 2, of the hydraulic main. In that plan, the pipe which conveys the gas into the condenser is shewn at E; having there entered, it passes between the upright plates in the direction of the arrows till it reaches the exit-pipe F, and that pipe leads to the purifying apparatus. It is to be noticed, that these upright plates do not rise to the top of the condenser—there is a space of about six inches left between it and the plate which fits over them. The entrance and exit-pipes E and F are placed about a foot from the top of the vessel, as shewn in the transverse section, fig. 3. The range of cast-iron plates, *a a a a*, in the hydraulic main mentioned above, do not lie perfectly horizontal, but with a small declivity to the right, by which arrangement the condensible matter drains towards the openings *a b c*, fig. 2, and thence by the pipe *a*, shewn in the figure of Mr. Malam's condenser, and *a b c*, fig. 3, is discharged into the receptacle E, which runs across the vessel, and is filled with water for the pipes to dip in, and form an hydraulic joint. It follows, therefore, that as the condensible products accumulate, they overflow the partition which forms the part F, and run into the chamber G, from whence, when it is necessary, they are drawn off by the cock H, in the two figures of the hydraulic main, and the condenser.

A B C D, fig. 2, is a plan of this condenser, the arrangement of which is already described; and fig. 3 is a transverse section of the same vessel. The following are different sections of the condenser, for which Mr. Perks obtained a patent:—The first figure is a plan of the top, shewing the situation of the bend-pipes, &c. Fig. 2, is a plan of the underside of the plate, on which the upright pipes are supported, shewing the openings into the lower chambers, and the position of the upright partitions.

Fig. 1, in the next page, is a side view (in elevation) of the vessel, the side plates being supposed to be removed. The pipe and bend beneath are for carrying off the condensations. The dotted line shews the height at which the fluid will be constantly kept in the vessel. An opening is made, or left at the bottom of each partition, which allows the condensed matter to flow from one to another, and to be carried off by the pipe. Fig. 2, is an end view of the vessel, (in elevation) the plate being supposed to be removed.

In considering the merits of either of these vessels, the most striking are the facility with which any obstruction to their operation may be removed, and the very efficient means they afford for answering the purpose of the manufacturer, as far as relates to the gas generated, being well condensed before it is brought to the purifying apparatus. We have already stated the distance which the gas would have to travel in passing through a condenser constructed on Perks's principle; and, when we consider that the pipes therein are always surrounded by cold water, we can hardly doubt of its effect. In his vessel the bends at the top are easily removed in the event of any obstruction presenting itself, and by forcing down each of the pipes a rod for the purpose, the passage is cleared. As there is a sufficient opening left at the bottom of each of the partitions in the lower vessel, the obstructing matter can be withdrawn from thence. In Malam's condenser the top can be removed, and after it is so, the cast-iron plate which rests upon the upright ones can be withdrawn also: so that the operator has it in his power, by drawing an instrument made for the purpose between the plates, (for the passage of the gas) to clear them out, and to open the holes through which the condensations descend into the lower chamber. It would appear that Malam, in the construction of his latter vessel, as well as the former, had considered, when gas passes through circular pipes, that which is near the centre would be little, if at all, acted upon by the cold medium surrounding them; and he has therefore compensated for that defect by causing the gas to present itself in such thin sheets as cannot fail to be affected by the coldness of the adjoining surfaces; thus giving a greater probability to the condensation being well performed. The present form of the hydraulic, in its most improved state, is that of a semicircular pipe, having covers or doors that can be removed at pleasure, and to which the pipes from the retorts are connected. This main contains a quantity of tar, into which the pipes from the retorts immerse a few inches. The tar thereby acts as a valve to prevent the return of gas into the retorts while in the act of charging. Formerly, the main consisted of a square chest for each retort, placed below, which received the dip-pipes in the same manner as the others, with pipes communicating between each chest; but from its near situation to the retort, the tar being continually impregnated with hot gas, hardened into pitch, and choked up the passage. From the difficulty of removing these obstructions, and the danger attending them, this sort of hydraulic main has been given up, and the form referred to substituted in its stead.

Fig. 1.

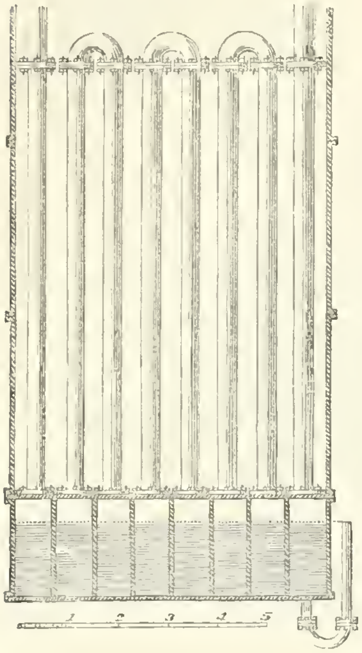
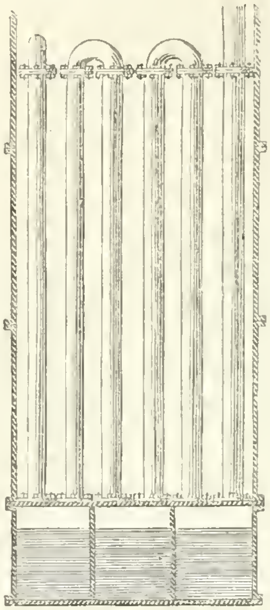
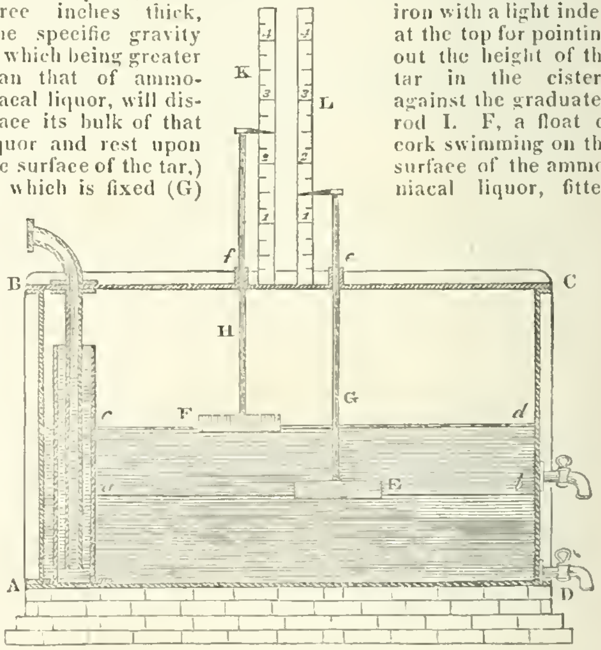


Fig. 2.



From these difficulties, and other considerations of convenience, the hydraulic main in the several works in England, as well as in the works here, is now elevated a few feet above the range of the retorts, so that the gas, instead of a downward direction which it formerly took, ascends into this as a reservoir, by means of which the tar, in a state of vapour, is longer detained in the retort; and, in a considerable degree, (compared to what took place formerly,) is decomposed into gas. In the alteration of the construction of the works here of late, as well as in those lately fitted up by me at Kilmarnock, we have not only taken advantage of this vertical elevation of the hydraulic, but have also, by the peculiar construction of the roof, set off the hydraulic at eight or ten feet distance from the retort, in a horizontal direction, by means of which its connexion with the retort is at a distance of about sixteen feet; the union pipes forming in one line a vertical direction, and in the other a line inclining upwards to the hydraulic, into which they dip. By this lengthened elevated line, the tar in a considerable degree deposits itself, and returns to the retort to be decomposed anew. This mode of arrangement in the fitting up of the hydraulic has also the advantage of a free circulation of the surrounding air, by which means it forms in some degree a refrigeratory for cooling the gas, and thereby depositing several heterogeneous particles of tar and ammonia that were still held in a state of vapour. It has also the convenience of being easily got at to remove any obstruction that may generate in this part of the apparatus.

Apparatus for shewing the exact Quantity of Tar and Ammoniacal Liquor produced from a given Quantity of Coal.—To obtain a correct account of these products, Peckston constructed a table for shewing the exact number of ale gallons contained in the tar-cistern at every inch dip; the application of which shall be shewn after describing the apparatus attached to the cistern. Considering that the specific gravities of tar and ammoniacal liquor were different, and that a body which would sink in the latter would swim upon the surface of the former, he proposed that two floats should be made, and attached to rods for shewing the respective heights to which each product rose in the cistern. In the annexed figure, A B C D, is a section of the tar-cistern. *a b*, surface of the tar. *c d*, surface of the ammoniacal liquor. E, a float of sound dry oak, twelve inches square, and three inches thick, (the specific gravity of which being greater than that of ammoniacal liquor, will displace its bulk of that liquor and rest upon the surface of the tar,) to which is fixed (G) a small rod of round iron with a light index at the top for pointing out the height of the tar in the cistern against the graduated rod I. F, a float of cork swimming on the surface of the ammoniacal liquor, fitted with a rod H, and an index for shewing on the graduated rod K the number of feet and inches the surface of that fluid is distant from the bottom of the cistern. The difference between



the heights, as pointed out by the indexes on the graduated rods I and K, is the feet and inches of ammoniacal liquor in the vessel. *e* and *f* are two raised openings on the upper plate of the vessel, of about five or six inches in height, through which the rods G and H slide up and down. By this contrivance they are steadied and always kept in a vertical position. This description of apparatus will answer for any tar-cistern; but as that vessel may be of different dimensions in different establishments, the table for use must be calculated accordingly.

Application of the Table.—Example. The index of the rod G pointing to two feet six inches on the graduated rod I; required the number of gallons of tar answering thereto? Look for two feet in the side column, and run your eye along the line till you come under six inches in the top one; you will there find 3,080 the number of gallons sought.

To find the Gallons of Ammoniacal Liquor.—Subtract the height pointed out by the rod G from that shewn by the rod H, and with the remainder enter the table as above directed; and you will find what number of gallons of ammoniacal liquor are in the cistern.

Example. The rod G stands at two feet six inches, the rod H at four feet; what number of gallons of ammoniacal liquor are there in the cistern? Ft. In. Ft. In. Ft. In. 4 : 0—2 : 6 = 1 : 6, opposite to which, in the table, find 1,848, and such is the number of gallons of ammoniacal liquor in the cistern.

Purifying Vessels, and the best Mode of Purifying Coal-Gas.—During the process of decomposing coals in close vessels, it is found, that, on their being heated to a certain degree, a part of the carbon of which they are formed unites with part of the oxygen, and produces carbonic acid; this, by means of caloric, is turned into carbonic acid gas. Whilst this process is going on, a part of the hydrogen of the coal is combined with another portion of carbon and caloric, which forms carburetted hydrogen gas. Olefiant gas, carbonic oxide, hydrogen and sulphuretted hydrogen, are also produced. According as the component parts of the coal submitted to distillation varies, so will the quantities of these products vary also.

When the gas produced from coal is burnt without being purified, (that is, deprived of the sulphuretted hydrogen and carbonic acid gas which it contains,) or if it be not properly purified, it throws out sparks and produces a sulphureous acid, owing to the oxygen of the air uniting with the sulphur burnt with the gas. Such gas sends forth a suffocating odour, that is not only highly offensive, but injurious to health. Its levity carries it to the uppermost part of the room where it is burnt, and there it is easily perceived. It tarnishes all metallic substances, and discolours paintings wherever metallic oxides may have been used in their execution.

The general way of freeing it from sulphuretted hydrogen and carbonic acid, and rendering it fit for use, hitherto adopted, has been by passing it through a solution of lime and water of the consistence of cream. It may also be purified by passing it through very dilute solutions of subacetate of lead, green sulphate of iron, or hyperoxymuriate of lime. For the purification of coal-gas, when it is manufactured in the large way, various methods have been adopted. The following are those most noticed:—1st, By passing it through lime in solution; 2d, By allowing it to be acted upon by lime in a semi-fluid state; 3d, By passing it through dry lime; and, 4th, By passing it through red-hot tubes into which are introduced clippings of iron.

The best arrangement for these vessels which has fallen under my notice, as well as the construction of the purifier itself, was effected by Mr. Malam, of the Westminster gas works. A B C D, fig. 1, (see the Plate,) is a vertical section of the treble purifier, placed upon a foundation of brick-work; and fig. 2 of the same Plate, is a plan thereof. E E, F F, G G, fig. 1, are sections of the three interior chambers, bolted to the tops of their respective vessels by the flanches expressed in the Plate. It will be observed, that the bottoms of these vessels branch out with a kind of flanch, by which means the gas is acted upon by a greater proportion of the purifying mixture than if the vertical sides of it fell in a perpendicular line. H H is the axis on which the agitator I I is fixed. K K K are three cylindrical vessels for the purpose of charging the respective vessels into which the purifying mixture is introduced by the bends L L L. M M M are the pipes which convey the gas into the interior chamber. N is the pipe which conveys the purified gas to the reservoir after it has passed through the series of vessels. O—the feed-pipe for bringing the purifying mixture from the vessel where it is prepared into the purifying apparatus. P P P exhibit the openings near the bottoms of the cylindrical vessels K K K, for emptying the respective vessels, which is effected by the slide-cocks Q Q Q. In the figure, the height to which the purifying mixture rises, is shewn in the two lower vessels; but the upper one is not charged. The agitators are drawn by hand in the same way as has been already described when speaking of the single purifiers. When this purifier is first brought into action, the purifying mixture is turned into the uppermost vessel K, from whence it enters into the uppermost purifier by the bend L, till it rises to the height of the uppermost edge of the vessel K. When such is the case, by opening the uppermost of the slide-cocks Q, that charge is emptied from the first into the second vessel, which being done, the uppermost purifier is again charged. The middle cock Q is then opened, which allows the charge in the second purifier to enter into the lowermost one, and whilst this is performing, that in the uppermost one is emptied into the second. The mixture is at the same time entering into the uppermost one, which is known to be properly charged, when the mixture rises to the top of its supplying vessel K. This being performed, the gas in its crude state is allowed to enter into the interior chamber of the lowermost purifying vessel by the pipe M, which being filled, it blows underneath the flanch part of it into the outer part of that vessel which is unoccupied by the purifying mixture: from thence, by the next pipe M, it is conveyed into the interior chamber of the middle purifier, where the action is the same as in the lower one; and thence, by the uppermost pipe M, it is conveyed into the highest vessel, where having again undergone the purifying process, it is allowed to enter the gas-holder by the pipe N.

On examining the Plate, it must appear obvious that the gas enters into the lowermost purifier in its most crude state; where, having been acted upon, it rises into the second in a purer state, and from thence into the top one. Under such circumstances, it follows, that the charge in the lowermost vessel is rendered useless first: on its being so, it is turned off by opening the bottom cock Q; whilst this is performing, the gas generated has to pass through two vessels before it can enter into the gas-holder: but, in the single purifier during the time of charging, the gas passes into the gas-holder in an impure state, thus, by mixture with the pure gas, deteriorating its quality. The bottom purifier being emptied, the mixture in the second is turned into it, and that of the top into the second, when the top one is recharged. The lowermost vessel then always contains the mixture which has been most acted upon by the gas. By the vessels being placed in this way, a considerable saving in the expense of erecting them is effected: for, the top of the lowermost vessel answers as a bottom to the second, whilst the top of the middle vessel is the bottom of the upper one. The saving is not there alone; for, if the vessels were placed separately, they would require to be fitted with a number of valves and connexions, under this arrangement altogether unnecessary.

Where the manufacturer has plenty of room on his premises for erecting a series of single purifying vessels, the extra expenses arising from the adoption of such plan not only consists in the first cost, but afterwards also, by requiring a man to work the agitators of each vessel; consequently, when three vessels were used, three men would be required for the purpose, whilst in Malam's purifier one man with ease works the three sets of agitators. His arrangement possesses another capital advantage, for in most large towns where coal-gas manufactories are established, it is of considerable importance to save room, and nothing can be better adapted for doing so than his triple purifier.

A mode of purification, differing in principle and practice from that we have mentioned, is by causing the crude gas to pass through retorts of a particular description, worked at a red heat just visible by day-light. Mr. G. H. Palmer obtained a patent for this invention. Fig. 3, in the Plate, represents a longitudinal section of Palmer's purifier, and fig. 4, a front view of the same, with the mouths of the upper purifier closed, and the lower one open. This purifier is constructed of cast-iron, and it is set in brick-work under such an arrangement as admits of its being heated to the temperature required. In the Plate just referred to there are two purifiers heated by one fire. In no establishment can the process be carried on with a less number; in large works it would not only require the magnitude of the purifier to be increased, but it would also be requisite to employ a greater number of purifiers also. The purifiers are of an elliptical shape, and each one is divided into two equal parts by a vertical partition, which runs along its centre from the mouth-piece to within a few inches of its end. The mouth-piece is double, that is, it admits of two lids being applied to it, one of which is to the right of the partition we have just spoken of, and the other to the left. The lids of these mouth-pieces are secured in the ordinary way by means of luting and cross-pieces. As it is intended that but one of these purifiers should be brought into action at one time, the apparatus is provided with the double mercurial valve A, fig. 5, the rod of which being attached to one end of a chain, (running over a pulley,) at the other end sustaining a counter-balance weight, the gas is allowed to enter into the upper or lower purifier as occasion may require; the valve being so contrived, that when the crude gas is admitted through it into one purifier, it is effectually excluded from the other. It is of considerable importance to the purification of gas by this mode, as well as every other, that it should have effectually undergone the process of condensation, and as the admission of any of the condensible products into the purifier will materially tend to clog it up and to prevent the play of affinities required in this mode of purification, the patentee advises that the pipes conducting the gas from the condenser should rise towards the purifying apparatus. In fig. 5, the entrance and exit pipes are exhibited: the latter dip into a square box containing water, into which they are immersed so as to form an hydraulic joint between the purifying apparatus and the gas-holder. This box is furnished with a pipe for conveying off any products which may be condensed after the gas has passed the purifier, and it will of course require another vessel for receiving them, which must be constructed on a plan somewhat similar to the tar-cistern, but on a smaller scale.

When this purifying apparatus is to be brought into action, it is to be at such a temperature as we have already stated, not that it is essential towards effecting the purification of the gas, but tending to the preservation of the vessel. This being effected, each compartment thereof is to be half or three-fourths filled with fragments or refuse clippings of sheet-iron, with tinned iron plates, argillaceous iron ore, iron-stone, &c. &c. It is to be noted, that whatever material may be used in this purifying vessel, such must be arranged in it so as to lie loosely together, in order that the gas may act upon as much of its area as possible, and that the sulphuretted hydrogen and carbonic acid gas may be thereby arrested. Should the black oxide of iron be used in the purifier, which appears to be preferred by Mr. Palmer, the operator should be careful as to the manner in which he disposes of it: always recollecting that a sufficient space should be left at the end of the purifier to allow the gas to pass round the divisional partition.

The purifier being charged with any of the materials as above specified, the lids are to be secured and the valve opened towards the one so charged by raising or lowering the counter-balance weight of the valve, according as the upper or lower purifier may be brought into action. The gas then enters into that compartment of it which is to the left, and passing over the iron, or whatever else may be introduced round the divisional plate, is allowed to pass from the purifier by means of the pipe which is connected to the mouth-piece, which is to the right, into the hydraulic box, and thence by the pipe B to the gas-holder, to be stored up for use as occasion may require.

It is requisite that tests should occasionally be taken, in order that it may be known when the fragments of iron, &c. become inadequate for the purpose of purification. When they are so, the other purifier is to be charged in a similar way, the mouth-piece secured, and the valve opened into it, which, as we have before observed, will shut off the communication to that which had been in action. When this is done, let the lids of the purifier which is out of use be removed, so as to admit the atmospheric air into it, the action of which will, prior to the purifier in action being rendered inadequate to perform its office, so far restore the materials to their proper tone, by reducing the sulphuret of iron again to a metallic state, as to allow the change of purifier to be again effected, and the process to be carried on to advantage.

The operator is invariably to follow the mode pointed out, by using his purifiers alternately, till it is ascertained that the iron, or whatever substance may have been introduced, will no longer retain the sulphuretted hydrogen, &c. When such is the case, the contents of the purifier must be removed, and replaced by fresh material, and the process proceeded upon again, in the manner we have already described.

When lime in solution is used for the purification of gas obtained from most of the species of Wallsend coals, a bushel and a half (Winchester measure) or 3225,63 cubic inches of unslaked lime is found sufficient for purifying 10,000 cubic feet; its value, at fourteen shillings the hundred, being about eightpence. In the same proportion must the purifier be charged for either greater or lesser quantities of gas generated. However, as the qualities of coals vary considerably, perhaps no specific quantity can be put down as a general rule. The operator will very soon ascertain the fact, for his tests will prove whether the gas be pure, and he will charge his vessel accordingly.

TABLE, *shewing the Comparison between the Lime Hundred and Winchester Bushel, &c.*

A hundred of lime is equal	to 21,696, or 21$\frac{5}{7}$ Winchester bushels of 2150,42 cubic inches each.
	to 27 cubic feet.
	to 46656 cubic inches.

Most kinds of quick lime double their bulk by slacking.

Many alterations have, at different times, been made in the structure of lime vessels for purifying coal gas; and, until lately, it does not appear that any form was hit upon sufficiently powerful to separate entirely the sulphuretted hydrogen. This is now effected. The gas at present made in the Glasgow gas works seems to be entirely free of it, and will not tinge either silver or gilding; nor can the acetate of lead, a delicate test, discover in it any of this offensive mixture.

On the Gas-holder (Gasometer); *its Construction, and Descriptions of such as would best answer the Purpose of the Manufacturer.*—The gas-holder (or, as it is more commonly, though improperly, called the *gasometer*,) is that vessel in which the purified gas is stored up for use. It has been of various sizes and shapes: that most generally adopted in large works is from 15,000 to 20,000 cubic feet in capacity. It is a cylinder; the diameter being from thirty-three to forty feet, and the height from eighteen to twenty-three feet.

When speaking of the gas-holder, we are to consider it as composed of two distinct parts; that is to say, a capacious inner vessel, in large works generally made of sheet-iron, which is closed at the top and open at the bottom: and a cast-iron tank or wooden vat of about a foot or eighteen inches greater diameter for containing water, into which the gas-holder sinks as it is emptied of gas, and out of which its lower edge, when full, cannot rise. By this contrivance the gas is prevented from escaping.

The gas-holder is suspended by a chain over two grooved wheels, fixed on a cast-iron frame placed over it; one end of which chain is made fast to an eye-bolt at the centre of the top of the gas-holder, and to the other is attached a frame supporting weights nearly equal to the weight of the gas-holder. It is to be observed, that by putting more weights upon the balance support, or frame, the gas-holder works at a less pressure, and, consequently, does not force the gas into the street mains with such velocity as when the weight is there decreased; for if the balance-weight, and weight of the gas-holder, were very nearly equal, there would be little or no impetus for discharging the gas: it would, in consequence, escape with such languor at the orifices of the burners as to afford but a very feeble light. To obtain a good light, the gas-holder should never be worked at less than about two inches' pressure; or, in other words, the surface of the water inside the gas-holder should be about two inches below the surface of the water contained between the outside of the gas-holder and the tank, or vat, in which it is suspended.

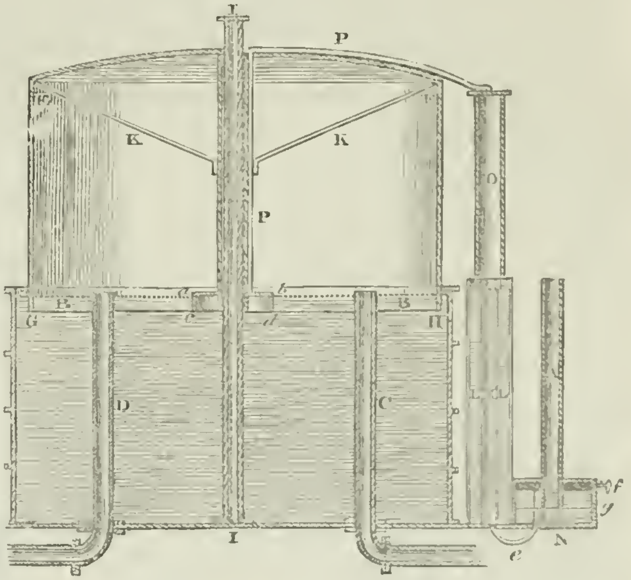
For ascertaining the pressure at which the gas-holder works, a small pressure-gauge may be attached to the top of it, and secured from accident by a wrought-iron case. When, from the gas being turned into the gas-holder, it has risen but a few feet out of the water, the operator, by inspecting the graduated scale on the pressure-gauge, can see what pressure the gas-holder is then working at; and, by diminishing or increasing the counterpoise, or balance-weight, regulate the pressure to what may be desired. One of the uses of the gas-holder is to regulate the emission of the gas towards the burners, which could not be effected without such contrivance.

We are now to describe the cylindrical gas-holder. In the Plate, fig. 1, is a vertical section thereof, and of the tank, &c. As the construction has been spoken of, I have here only to notice the particular parts as exhibited. A B C D is a section of the gas-holder, E F G H a section of the tank, I I cast iron flanch-pipes jointed together in the usual way, as columns for supporting the frame K K. Upon this frame are placed carriages for bearing the grooved wheels L L, over which runs the chain suspending the gas-holder and balance-weight M. N is the pipe bringing the gas into the gas-holder, after it passes from the purifying apparatus. O, another pipe similar to the former, by which the gas is discharged into the mains when wanted for use. It need hardly be remarked, that these pipes must rise a few inches above the level of the water in the tank, to prevent a possibility of water getting into them. Upon the horizontal parts of the pipes N and O are placed valves for shutting off the respective communications when the vessel is full, or when it may be desired not to work into it. The figure represents the gas-holder as if it were about half filled. Fig. 2 represents the plan of the gas-holder just described. This is the most simple construction of gas-holders for working on the ordinary principle that has hitherto been adopted.

Malam, to obviate the necessity of having all this heavy framework, proposed to erect gas-holders working with the specific gravity apparatus without it; and to shew the possibility of doing away therewith, in the spring of 1817 he constructed a model. If we consider the tank and gas-holder to be such as have been just described, the following description will explain his principle. In the centre of the tank he proposed to form a cylinder of about four or five feet diameter, of cast-iron flanch plates, with the flanches inwards, so as to present an even surface outside. This cylinder was to be made tight to somewhat above the height of the tank: it was then to be carried by open castings to above the height that the top of the gas-holder might rise. The top of it was cast with a strong broad flanch, strengthened by vertical flanches underneath it,—thereon were bolted carriages for supporting two small wheels in a right line with each other, and with the centre of the cylinder. Over these wheels run two light chains, by which the gas-holder and balance-weights were suspended. It will be clear, that under such arrangement, as the gas-holder rose out of the water, the balance-weights would descend in the cylinder I have been describing; and as it would be sufficiently capacious for them to pass up and down in, they would be quite out of the way, which in many cases is a desideratum. The expense of the cylinder would be considerably less than the most common frame could be put up for, and it would answer instead of steadying columns, without which gas-holders working vertically are very liable to swing towards one side of the tank, and falling out of a vertical position, to hang, or to work very unpleasantly.

In a tank of thirty-five feet diameter and eighteen feet deep, the gas-holder will hold about 15,400 cubic feet of gas, when constructed with the framework, &c. in the usual way. By Mr. Malam's arrangement, should the gas-holder be made of the same diameter, having a cylinder of five feet diameter for the balance-weights to work in, it will still contain 15,000 cubic feet, so that its capacity is not thereby considerably lessened. By it, the first cost of erecting a gas-holder of 15,000 cubic feet capacity, will be decreased £200, or £250. It will, of course, require that the gas-holder should, in this case, be made so as to exhibit in the plan two concentric circles; one of which would be the diameter of the gas-holder, and form its sides,—the other, or interior, that which clipped round the cylinder, and of so much greater diameter as would allow it to slide up and down upon it freely. It would be riveted to the top of the gas-holder in the same way as the outer one, and made firm by one piece of angle iron going round its top, and another round the bottom.

But this gentleman, on pursuing his inquiries still further, proposed to work the gas-holder without using chains or balance-weights; yet in such a way as to have the pressure uniform at all its heights; and to exemplify the possibility of the thing being effected, he constructed models of different dimensions. By describing the following figure, which is a vertical section of this gas-holder, the reader will understand the principles on which it is constructed so clearly as to render it quite familiar. The tank for this gas-holder is in all respects similar to that used for others which work vertically. It is filled with water to the height expressed by the dotted line B B. C is the pipe which brings the gas into the gas-holder, and D the pipe of exit therefrom. The gas-holder E F G H, when of 15,000 cubic feet capacity, is constructed of No. 16 wire-gauge plate iron. It is concave-shaped at the top, in order that if it should be erected in the open air, no lodgment of water, &c. may remain upon it so as to increase the pressure. From the centre of the bottom of the tank rises a cast-iron column I, I, of about thirty-five feet in height; this acts as a guide for keeping the gas-holder in a vertical position, which is effected either by a pipe, (whose inner diameter is about half an inch more than the outer diameter of the column,) bolted to the top of that vessel inside, and braced to the upper edge thereof by a sufficient number of rods as K K, or otherwise by a tube of plate-iron of the same dimensions secured in a similar manner. At the centre of the bottom of the gas-holder is placed an air-vessel *a b c d*, constructed of plate-iron, the top of which is to be situated at such a height as to be level with the surface of water in the tank when the gas-holder is at its greatest rise. This air-vessel is to be of the capacity of such a bulk of water as is equal in weight to the actual weight of the gas-holder, less the pressure it may be intended to be worked at. For finding the dimensions of air vessels, for gas-holders of any capacity, is subjoined the following



Rule.—Given the diameter of the gas holder, its depth, and weight, together with the pressure at which it is intended to be worked, also the depth proposed for the air-vessel, to find its diameter:—

First:—Find the area of the base by squaring its diameter in inches, and multiplying that square by the area of unity ,7854.

If the gas-holder work at one inch pressure, the area so found will be the number of cubic inches of water displaced, consequently, multiplying it by the number of inches of pressure which it may be worked at, will give the number of cubic inches of water displaced at that pressure.

Divide the inches so found by 1728, which will reduce them into cubic feet. These multiplied by 1000 ounces, the weight of a cubic foot of water, gives the weight in ounces, which may be reduced into tons, &c. in the usual manner.

Subtract this weight from the weight of the gas-holder, and the remainder shews the weight of such a bulk of water as is equal in weight to the absolute weight of the gas-holder, less the pressure it is to be worked at.

Reduce the weight last found into ounces, and divide by 1000, the quotient shews the capacity of the air-vessel in cubic feet.

Divide the capacity of the air-vessel just found by its depth in feet, the quotient will be the area of its base in square feet.

Now as the air-vessel is cylindrical, to find its diameter, say As 355 : 452 : : so is the area to the square of the diameter.

The square root of the last result is the diameter required.

Example.—Given the diameter of the gas-holder 33 feet, its depth 17 feet, and weight 3 tons 15 cwt.—It is to be worked at inch-and-half pressure, the depth of the air-vessel being one foot, to find the diameter of that vessel:—

First 33 feet = 396 inches.

Then 396 × 396 × ,7854 = 123163,2864 superficial inches, the area of a circle whose diameter is 33 feet in inches.

123163,2864 × $1\frac{1}{2}$ = 184744 (nearly) cubic inches of water displaced at $1\frac{1}{2}$ inch pressure.

184744 ÷ 1728 = 107 cubic feet of water nearly; 107 cubic feet of water is equal to 107000 ounces, or to tons 2, 19, 2, 13.

Then tons 3, 15, 0, 0.—Tons 2, 19, 2, 13 =
Cwt. 15, 1, 15, or 27568 ounces.

27568 ÷ 1000 = 27,568 cubic feet, the capacity of the air-vessel.

27,568 ÷ 1 = 27,568, the area of the base of the air-vessel in square feet.

To find the diameter, say

As 355 : 452 : : 27,568 : 35,1, the square of the diameter.

$^{2}\sqrt{35,1} = 5,92$ nearly,—

therefore, for a gas-holder of the dimensions and weight as above given, and working at inch-and-half pressure, it would require an air-vessel one foot deep and five feet eleven inches in diameter.

A vessel of the size just described would be sufficient so to buoy up the gas-holder when full, as to allow it to stand at a certain pressure; but as it descends into the water in the action of discharging its contents, its weight would decrease from the circumstances explained heretofore, when speaking of gas-holders working by weights and chains; therefore, unless the air confined in the vessel could in some way be disposed of, the pressure would be continually changing. To obviate this difficulty, Malam proposes the following appendages to the gas-holder. A pipe L L, of eight inches diameter, equal in height to the height of the tank, enclosing within it another pipe of the same height of two inches diameter, marked M in the figure. From the pipe M there is a communication to the vessel N by means of the small bend-pipe *e*, which rises to nearly the top of that vessel. Through the top of the closed vessel N is brought the vertical pipe A, which descends nearly to its bottom, and rises to a height equal to that of the tank of the gas-holder. This pipe is of such a diameter as to make it equal in capacity to the water displaced by the gas-holder when quite down.

In forming rules for calculating the capacity of the compensating pipe A, and the vessel N, we proceed as follows:—

First, find the circumference of the gas-holder thus, as 7 : 22 : : the diameter to the circumference:—then multiply the circumference by the depth of the gas-holder, and that again by the weight of a square foot of the material of which it is to be formed, adding the necessary weight for rivets, and the weight of that part which will be immersed in water, will be known. To find its bulk, say

As the specific gravity of the material of which the gas-holder is composed
Is to the weight last found reduced into ounces,
So is one cubic foot
To its magnitude in cubic feet.

This magnitude divided by the height of the pipe A, will give the area of its base. The diameter of which may be found by the rule already given for finding that of the air-vessel.

Example.—Given the diameter of the gas-holder 33 feet, the depth to which it is immersed in water 17 feet, the weight of a square foot of the material of which it is formed (plate-iron) 2 lbs. 11 oz.;—its specific gravity being 7645,—to find the diameter of the compensating pipe A, its height being 17 feet:

First: as 7 : 22 : : 33 : 103,7 the circumference 103,7 × 17 = 1763 nearly.

Then 1763 × 2 lbs. 11 oz. = 4838 lbs., to which, if we add 762 lbs. as an allowance for rivets, &c. we have 5600 lbs. or 89600 ounces, for the weight of that part of the gas-holder which becomes immersed in water. To find its bulk, say

As 7645 : 5600 : : 1 : 11,72 cubic feet nearly. 11,72 ÷ 17 = ,69 (nearly) the area of the base of the pipe in question.

For the diameter,

As 355 . 452 : ,69 : : ,8785 the square of the diameter

$^{2}\sqrt{,8785} = ,937$, or $11\frac{1}{4}$ inches nearly. Therefore the compensating pipe for such a gas-holder would require to be $11\frac{1}{4}$ inches in diameter.

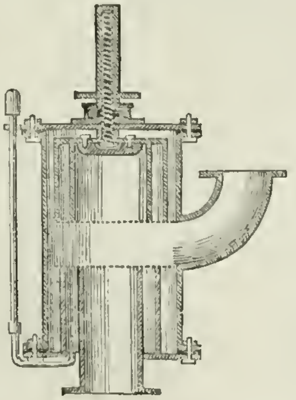
As the vessel N is connected by the bend *e* to the upright pipe M, and that to the air-vessel by the pipe O, (which rises and falls with the gas-holder between the pipes L and M, the space being filled with water so as to form an hydraulic joint,) and the small pipe P P, which runs along the top of the gas-holder, and from its centre descends into the air-vessel, it will be evident that if this gas holder be brought into action, it must be prepared for use in the following manner. We will suppose the gas-holder to be down in the tank, which is filled with water. The pipe L L is also filled with water to within a few inches of the top. Then into the vessel N let the water be poured by means of the upright pipe A till it runs out at the cock *f*, that cock being situated at such a height as will indicate, when, by pouring in more water, it would descend in the bend *e*. Things being thus prepared, attach the condensing apparatus to the cock *f*, which is fitted with a screw for receiving it, and inject air till such time as the water from the vessel N rises to the same height in the pipe A as it is in the tank of the gas-holder. When such is the case, part of the vessel N, from the top to the dotted line *g*, will be filled with air, as will also the bend *e*, the pipes M and O, and the small pipe P. Whilst this is performing, it is evident that the air will be thrown into the air-vessel; for if we suppose the water to have risen to the same level in the pipe A, that it is in the tank, there must be the same pressure upon the air in the vessel N, as in the air-vessel *a b c d*, and the air will be equally condensed in each. But as the air-vessel will not then be filled with air, it must be considered under like circumstances with a vessel of any sort inverted into water. If a vessel be pushed or let down to any depth in that fluid, then by the pressure of the water some of it will ascend into the vessel, but not so high as the water without, and will compress the air into less space, according to the difference between the heights of the internal and external water. Should the tank be about thirty-four feet in depth, the air-vessel would, with such pressure, have the weight of two atmospheres upon it, and the air therein would be compressed into one half the space it would occupy when the gas-holder had risen to its greatest height, and the top of the air-vessel was level with the surface of water in the tank. This compression would, in a similar ratio, be increased or diminished with a greater or less depth. Considering these points, it follows that the capacity of the vessel N must be such as to contain a sufficiency of water for filling the pipe A between about two inches below the top of the bend *e*, and as much above the bottom of the pipe A, when the gas-holder is worked at inch-and-half pressure. The cock *f* being shut, and the condensing apparatus removed, if gas be allowed to enter into the gas-holder, the vessel will be caused to rise in the tank, and as it rises the column of water in the pipe A is depressed, and the air out of the vessel N passes into the air-vessel *a b c d*, thus increasing the buoyancy of the gas-holder in proportion to its rise, till it has attained its greatest height, and then all the air has been discharged from the vessel N into the air-vessel. This contrivance is well adapted for keeping up a regularity of pressure, and extremely simple in operation.

There have not been wanting other contrivances for working gas-holders by means of air-vessels, as Mr. Perks's, in which the air-vessel was closed, and attached to the interior of the lower edge of the gas-holder, and so constructed, that by the opening and shutting of valves to increase or diminish the pressure, by the admission of water, or by letting in of air. Another patent was obtained in 1819, by Mr. Outhett, of Lambeth, for a gas-holder working with air-vessels. His plan differs from both the former. The vessel for giving buoyancy to the gas-holder, being constructed of strong materials, is closed, and the air in it condensed to a very considerable degree, whilst the other, which answers for the compensating apparatus, is open. Both these vessels are placed a little above the centre of gravity of the gas-holder.

In addition to the list of gas-holders is one of Clegg's invention, with a very shallow tank, into which the lower edge is immersed. This gas-holder occupies a greater area of base than such as have already been mentioned. When it is full of gas, the end view is represented by an equilateral triangle, the bearings being from the angle opposite to the base. This gas-holder is so constructed, that the sides have a tendency to close with each other, and therefore when the valve of supply is opened, such tendency expels the gas. In this gas-holder it is evident, that some part of each end must be constructed of flexible materials. It is known to the gas-light manufacturer by the term "Collapsing Gas-holder."

Various Kinds of Valves, Syphons, and Tar Wells.—The necessity of adopting effectual means for shutting off all communication between the gas-holder and street-mains, as well as from one ramification of main to another, suggested the propriety of introducing valves upon the line of main-pipes. Those originally used by the gas-light companies were slide valves, similar to what are used by the water companies; but, such have now been long out of general use; and hydraulic, or pneumatic, valves, or combinations of both, have supplied their place. The valve seems to have undergone more changes in its structure than almost any other part of the gas-light apparatus; it appears to have been within the reach of most men, and, according to the abilities exerted, it has been altered. In some cases, change appears to have been the sole object in view, for alterations which did not lessen the expenses of construction, decrease the dimensions of the valve, or render it more effective, could not be termed improvements.

It will not be necessary to take up time in describing all the various kinds of valves which have been, and are now used. We shall describe but two, namely, an hydraulic and a pneumatic valve; the former being well adapted for use in the manufactory, and the latter for the street-mains. The annexed figure is a vertical section of an hydraulic valve, invented by Malam, which is particularly useful in the connexions about the purifying vessels, and on the works. This valve is cylindrical, flanched at top and bottom, and cast with a flanch quarter bend projecting upwards, from one side of the diameter required. At the bottom is bolted a double cup, which rises to the height of the lower part of the bend just mentioned. Through the centre of this cup is an opening of the same diameter with the bend. This centre part projects a few inches below the bottom of the valve, and is furnished with a flanch for jointing it to the pipe by which the gas is brought into it. Through the bottom of the valve is brought a bend of wrought-iron tube, as expressed in the figure, which is connected to an upright pipe of the same material, rising to the top of the valve, for introducing water into the double cup. the top of this supplying pipe is covered with a cap, which is screwed on, save when it may be necessary to furnish a supply of water. The top of the valve is covered with a blank flanch, which is jointed and secured thereto by screw-bolts in the usual way. At the centre of the top is fixed a stuffing-box, the bottom of which is tapped for receiving the square thread lifting-screw. This screw is surrounded by a wrought-iron case with a thread inside for receiving it. The case is moveable in the stuffing box, and of sufficient height to allow the lifting-screw to rise to the greatest height that may be required. It is furnished with two handles, which with it serve as a wrench for raising or lowering the screw. The bottom of this screw is secured to a double inverted cup, as shewn in the figure, and therefore that is lifted or lowered with it. The inverted cup is so constructed, as when let down to fall between the two circles forming the lower one; and thus, if we suppose the bottom cup to be nearly filled with water, and the upper one immersed into it, it follows that the valve so constructed is capable of sustaining double the pressure of that which is constructed with but a single cup, and under such arrangment it will not occupy more than half the room of the former, to be equally effective.



It may be worthy of remark, that the objections to the sufficiency of this valve have been most fully answered by the experience of several years. The action and counter-action of the inner and outer of the lower cups being reciprocal between each other, as must appear evident on examining the figure, renders it altogether safe. Fig. 1, is a plan of this valve, which, from what has been said, does not require further description. Fig. 2, is a vertical section of Malam's pneumatic valve, which from the stuffing-box at the top, to the step for the spindle at the bottom, is somewhat more than twice the diameter of the main on which it is to be used. Thus, for instance, from the top to the bottom inside of a fourteen-inch valve of this description, will be about three feet, and in a similiar proportion for smaller or larger ones. The body of the valve is square, as shewn in the plan, a few inches from the top of which is at one side a socket, and in a direct line with that is placed at the other side a spigot, in order that it may be introduced into the range of main-pipe as necessity requires. The inner faces of the socket, as well as spigot, project about an inch inward, and require to be chipped and filed so as to present perfectly plane surfaces. Through the top of the valve, which is fitted with a stuffing-box, is introduced the spindle, in such a way that the lower end of it rests in the step at the bottom of the valve, and the boss beneath brass couplings, or a collar in the bottom of the stuffing-box. So that when the stuffing-box is fitted, and the glan bolted down, should the wrench or key be applied to the square top of the spindle, it will turn freely round, but without being raised. If we then suppose the valve to be open, as shewn in the figure, there will rest upon the bottom two wedge-shaped pieces with their points downwards, and between them the frustum of a square. The spindle passes through the latter, which is fitted with a screw for receiving it, and it is thereby raised or lowered, and the valve shut or opened. Upon the centre-piece, at a convenient distance from the top, is bolted a spring, which is also connected to the side-pieces, so as to act between the top of them and the fastening bolt. In its natural

Fig. 1.

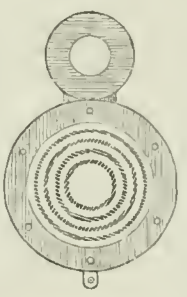
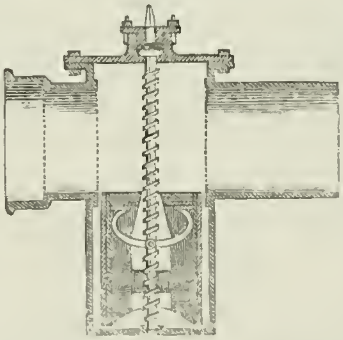
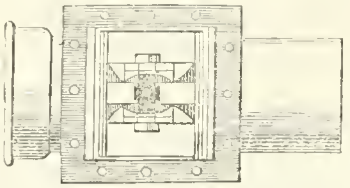


Fig. 2.



position it has a tendency towards drawing the side-pieces together, and of pushing the middle one downwards. This contrivance allows the three pieces to be lifted together, without being rubbed against the inside of the valve, till the outer pieces touch the top. The further ascent of the outer pieces being then arrested, the middle one continues to be raised by the screw till they are completely wedged up against the interior of the socket and spigot. And as these wedge-shaped pieces are faced with cork or leather, the pressure can be carried to such pitch as effects an air-tight joint upon each, thus effectually preventing the passage of the smallest portion of gas. When the valve is in such position, the spring will be elongated horizontally, and so remain till the screw is turned for lowering the interior pieces, when it again resumes its former shape, and thus draws the side-pieces towards each other, and pushes the middle one downwards. The annexed figure is a plan of this valve. It exhibits the flanch to which the top is bolted, the socket and spigot shewn in the former section, and the top of the inner pieces with the facings of cork. That this is an effective and simple valve, appears evident from barely inspecting the figure. It is of small size, and can be got up at a very trifling expense, when compared with others more generally adopted.



Syphons are of two kinds: the larger sort are distinguished by their diameters, two, three, or four inches, &c. syphons; the smaller, which are used on the service-pipes, are generally termed "gun-barrel syphons," or "bottle syphons." The shape of the vessel itself is similar in each case, but the furniture and use are different. The larger sized syphon is a cast-iron cylindrical vessel of about a foot deep, and of the diameter inside agreeable to its distinguishing name. It is flanched round the top, and to this flanch is bolted a blank flanch. Through the centre of the blank flanch a hole is drilled and screwed for receiving a piece of wrought-iron tubing, which descends nearly to the bottom, and projects a few inches above the top. Another piece of similar tubing is bent and screwed also into the top; thence rising nearly perpendicular, it is connected to the bottom of the main-pipe, from thence the water of condensation descends by it into the syphon.

The gun-barrel syphon is, in shape, nearly similar to that just described, but its dimensions are much smaller; namely, about eight inches deep, and four in diameter.

The tar-well, is a cylindrical vessel of about ten inches diameter inside, by twelve inches deep, when used upon all mains of less than ten inches diameter; but when it is used upon larger mains, the diameter of the body of the tar-well must be about two inches greater than the diameter of such main. This vessel is cast with a socket at one side, and a spigot at the other, similar to those of the pipes with which it is to be used; therefore, a tar-well with a socket and a spigot, similar to a two-inch pipe, is called a two-inch tar-well, one for a three-inch pipe, a three-inch tar-well, and so on.

Mains and Distributing Pipes.—In the present supplement to the Encyclopædia Britannica, it is stated, that a pipe of an inch bore will supply 100 jets; but it ought to be observed, that this only holds in peculiar circumstances. If we suppose a pipe of the above dimensions extended for 300 yards from the point of supply, we shall find that the jets will gradually diminish in intensity of light towards the extremity of such a pipe. It is, therefore, safer, even in point of economy, to calculate on the pipes being something above rather than below this statement, between the supply and quantity of light.

A want of experience on this branch of the establishment, and an increased demand for gas beyond what was calculated upon, has frequently created great trouble as well as very serious loss, not only in the works here, but in several of those in England. Accordingly, in some cases they have been obliged to lift and relay pipes of additional bore, and in others to lay down additional subsidiary mains. This has at no time arisen from any deposition of crystals or other matter in the pipes, so as to contract the area, but from want of sufficient practice to shew what dimensions under different local circumstances would be needful, and from the increased demand alluded to. Should you, therefore, suppose that an increase of light, to the extent of 10,000 jets, would take place in a few years, it would then be prudent that the mains for the proposed establishment should not be less than 19 inches in diameter, and that the other distributing pipes in the various streets of the town be proportioned in the same ratio; and this must be obtained by a survey of the shops and other establishments where gas-lights may be supposed to be taken in.

Valves and Water Traps.—The water valves which we should recommend as preferable to any other yet in use for shutting off the gas, must also be proportioned to the area of the pipes, where it shall be found needful to place them; and these, in all cases where they are needful, will serve not only as stop valves, but as drips to carry off the condensed vapours that collect in the pipes in a liquid form. The number of these necessary must also be ascertained by actual survey, and from the inclination of the streets.

Service and Inside Pipes.—The service pipes that branch off from the distributing ones, to convey the gas within such premises as are to be lighted, may be of cast-iron, varying from ¾ to 1½ inch bore, and upwards, as the quantity of light to be supplied may determine. The pipes that have hitherto been fitted up for shops and other manufactories, have for the most part been of wrought iron, which have been found to answer better than copper ones, which were at first in use; but of late, block tin pipes have superseded in a coniderable degree the others. Pipes of this description have advantages which strongly recommend them to consumers, and to manufacturers of gas. They are not acted upon by the gas so as to be corroded, nor does any matter adhere to their interior; consequently, any complaints or trouble that formerly occurred from these sources will be completely obviated.

Burners.—Argand burners of three different sizes, and jets of different figures, are pretty generally in use. Each jet is equal to the intensity of light of a candle and half, weighing six in the pound, and will consume about one cubic foot of coal gas per hour. The No. 1 argand burner is equal in intensity of light to three of these jets, and will consume only about two cubic feet of gas per hour. The light derived from such a burner being much greater in proportion to the gas consumed, than in burners of the jet form, some would strongly recommend that argands as much as possible be used, as a matter of material interest to a gas company, and of comfort to the community. Some of the works in England, aware of this, give out none but argand burners to their customers, except in cases where they use meters.

Apparatus for the Production of Gas for Illumination, from Oil, &c.—For the more general diffusion of the benefits arising from the use of gas-lights, where houses and manufactories are at a distance from towns, and where coals are scarce, and room scanty, Messrs. Taylor and Martineau, some years ago, invented and brought to great perfection, an apparatus whereby every purpose of economy is answered, and a most beautiful and splendid light is obtained merely from the distillation of impure oils, grease, &c.

A general idea of the process may be formed from the following account:—A quantity of oil is placed in an air-tight vessel, in such a manner, that it may flow into retorts which are kept at a moderate red-heat; and in such proportions, as may regulate the production of gas to a convenient rate, which may be easily governed by the will of the operator.

The oil, in its passage through the retorts, is decomposed, and converted into gas proper for illumination, having the great advantages of being pure and free from sulphurous contamination, and of supporting a very brilliant flame, with the expenditure of very small quantities. It will, however, generally be found that some oil passes off in the state of vapour, without being decomposed; and in order to condense this, and return it again into the oil vessel, the gas is made to pass through a vessel immersed in water, by which, and its exit by a worm, the vapour is condensed again into oil, and flows at once into the oil cistern, so as to come again into use in the retorts. As a further precaution to purify the gas from oil, which may be suspended in it in the state of vapour, it is conveyed into a wash vessel, where, by bubbling through water, it is further cooled and rendered fit for use; and passes by a proper pipe into a gasometer, from which it is suffered to branch off in pipes in the usual manner.

An apparatus, fit for a large establishment, and capable of producing from 1,600 to 1,800 cubic feet of gas at one operation, requires only the cleaning out the retorts, which becomes necessary from time to time, from the accumulation of a certain quantity of carbonaceous matter. This, and the necessary attention to keep up a moderate fire, is the only trouble which attends the use of the apparatus; and the time required for the production of the above quantity, would in general be about six hours. The number of lights which would be supplied by 1,800 cubic feet of oil gas, reckoning that they were argand burners, and employed for four hours, would be about 300, and giving a light equal to from 3,000 to 3,600 mould candles. In order to adapt them to different establishments requiring smaller quantities of light, and to fit them for private houses, they may be made of various sizes, accommodated to different degrees of power, and suitable, by the small space they occupy, for situations where much room cannot be spared. One capable of furnishing gas for from 12 to 20 argand lights, may be conveniently placed in a small kitchen fire-place, and will occupy a space of four feet by three, and a height of about eight feet.

For private houses, a gasometer should not contain less than from 80 to 100 cubic feet, and for larger establishments, they should contain from 300 to 600. There are great advantages in having the gasometer as large as circumstances will admit; in the first place, the demand of the longest night in winter should be provided for, and the increased consumption occasioned by lighting the greatest number of rooms for company. In the second place, both the trouble and expense of the gas is diminished by having a reservoir sufficiently capacious to hold some days' ordinary consumption, by which, as the gas improves by keeping, it is most convenient and economical to have to make it but once or twice a week.

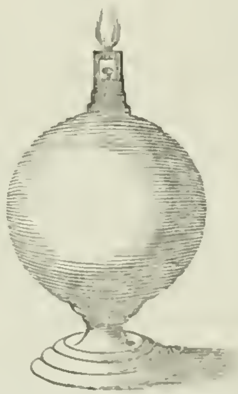
In a private house, where three or four rooms are adequately lighted, and where a small flame is kept burning all night in a bed-chamber, it has been found that from 20 to 30 cubic feet of oil-gas is sufficient; and therefore, a gasometer containing 100 feet will give a supply for four nights. Such a gasometer will be about six feet long and four wide, and rather more than four feet high. One for 400 cubic feet may be ten feet long, and seven wide, and about six high. There is no occasion that a gasometer should be placed near the other parts of the apparatus.

GAS *Light*. We will now give Professor Leslie's examination of the illuminating powers of oil and coal-gas, having shewn the manner in which each is prepared and dispensed in cities. The Professor's experiments were made at the request of the Edinburgh gas light company, and are confined to two points: 1st, The comparative density of the gases: 2dly, Their relative powers of illuminating.

"1st, The density of your coal-gas commonly does not much exceed *six tenths* of that of atmospheric air: When I began the operations, its density was only ·593; but it was afterwards ·618, and is now ·623. In winter I once found it to be ·680, and at another time as high as ·700, though it was oftener at ·600. The variation seldom, I presume, exceeds the *eighth* part. A small quantity of oil-gas, procured for the experiments, I found to have the specific gravity of only ·674, not greater indeed than that of your coal-gas, when made from the best coal. The oil-gas, however, furnished by Mr. Milne, manufactured on a small scale, and apparently with great care, at his works, was materially denser, being as high as ·913, though on a former occasion I found it to be only ·810. If we assume in round numbers the density of coal and oil gas to be six and nine-tenths of that of atmospheric air, it is easy to compute, that under the pressure of half an inch of water, the quantities discharged from the burner No. 1. of the oil-gas, which contains ten holes, each having the 1-40th of an inch in diameter, would be respectively $4\frac{3}{4}$ and 3 8-9 cubic feet. The quantities actually consumed, however, are only about the halves of these measures, because the aperture is always contracted by partly shutting the cock to bring the flame to the same standard height. When the flame is thus regulated, I find the consumption of the same gas, and with the same burner, always the same, whatever may be the load placed on the gasometer. For instance, after increasing the load four times, and consequently doubling the velocity of discharge, yet on adjusting the cock so as to reduce the flame to its former height, the expenditure of the gas was not altered.

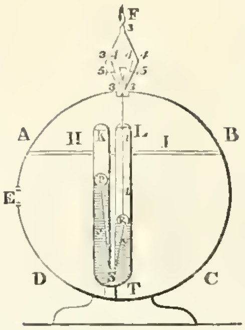
"2dly. The illuminating powers of the two gases were *measured* with great accuracy, by the application of my photometer, which I had somewhat modified to exclude every irregular influence of heat. The indications were steady and easily noted, nor could the judgment of the observer be liable, as in other cases, to any sort of bias or indecision. It hence appears to be ascertained, that with the same burner the powers of illumination of different gases, and of the same gas in different states, are very nearly proportional to their densities. The same *weight* of gas of any kind gives out the same quantity of light; but if equal *bulks* be taken, the illuminating powers follow the ratio of their densities. But the quantity of light emitted is not uniformly proportional to the measure of the gas expended. A certain burner, for instance, was observed to produce double the illuminating effect, though it consumed only one-half more of either species of gas. With No. 1. of the oil-gas burner, the relative illumination of Mr. Milne's oil-gas to that of your coal-gas, was found to be as six to five. But a cubic foot of the former lasted thirty-eight minutes, while a cubic foot of the coal-gas was spent in thirty minutes and a half. The relative volumes consumed were hence in the space of an hour 1·58 and 1·97, or in the ratio of four to five. Wherefore while five cubic feet of coal-gas give five degrees of light, four cubic feet of the best oil-gas give six degrees; that is, for equal volumes the illuminating power of the oil to the coal-gas is as *three* to *two*. The same conclusion was obtained on passing those several gases successively through the argand coal-gas burner No. 2. Thus the illumination of oil gas is actually less than the half of what has been currently asserted."

The Gas Burner.



The advantages of oil-gas are, that being free from sulpheretted hydrogen, it will not injure metallic goods, pictures, elegant bindings of books, or gilded furniture of any description; and will give out, when burning, only one half the heat of coal-gas. And the further advantages arising from the portable form in which it is now offered are—1st, That from being moveable, a less quantity of light will be required in an apartment than when the light is fixed in one place. 2dly, That it is capable of being economized, as a great or small number of the lamps may be lighted, and the strength of the flame diminished or increased at pleasure; the customer paying for no more gas than is used. And, 3dly, That the gas may be used in situations where it is impossible in any other manner to convey gas lights.

Portable Gas Lamp.—The following figure exhibits a different plan for burning gas, contained in a portable vessel, with an equal flame. A, B, C, D, is the vessel, E the opening at which the gas is forced in, by means of a pump, and F is the jet at which it escapes and is consumed. H, I, is a bar to support the gas tube K, S, L, open only at one end. The space from K, to the float P, contains mercury. The two floats, P and R, are connected by the string or chain X, Y; and to the top of the float R the stout wire Z, Z, Z, is attached perpendicularly. To the top of this wire is affixed a cubical piece of metal, shaped on *all sides* like a wedge. This is contained in a kind of box marked 3, 3, 3, 3, which is also shaped wedge-like, but with a greater angle at the bottom; 4, 4, are two metal plates, each exactly the same size as one side of the box. These plates are to be pushed backwards or forwards by the screws



5, 5, till the aperture is adjusted, when the ends of the screws may be cut off. Now, suppose the cubical vessel A, B, C, D, empty of gas, the mercury in the tube is alike high at both surfaces. The forcing pump is applied at E; and, as the gas is condensed, it compresses the air in the end of the tube at K: of course the mercury rises, carrying the float P up along with it; the other ball is drawn down, and brings down with it the wire Z, which gradually stops the opening at the top of the wire; and, as the gas contained is diminished, the pressure will be taken off the surface of the mercury at R, the air at K will expand, and raise the wire Z, and enlarge the opening.

The Portable Gas Company of London, have positively pledged themselves to the public, that every one of these lamps has been proved to resist a pressure of between 600 and 700 lbs. upon the cubic inch; and, that they will in no instance be subjected to a pressure of little more than 400; there will therefore be a surplus strength of 200 upon every square inch; or in other words, each vessel has sufficient power to receive a supply of gas nearly equal to fifteen *additional atmospheres!* The most timid need not then fear an explosion of these lamps.

Comparative Merits of Coal and Oil Gas.—A good deal of discussion has of late arisen regarding the comparative merits of these two gases, and so much has the subject been perplexed by the conflicting statements of rival manufacturers and companies, that the question can hardly yet be considered as settled, although the general impression undoubtedly is, that the coal gas, where coal is abundant, has the advantage in point of economy, though it is rather inferior to the oil in point of purity. As the subject has become interesting to the public, we shall state a few facts regarding it, which are, perhaps, not generally known, and for which we are partly indebted to an interesting report lately published by the Dundee Gas Company, and which forms the result of certain inquiries set on foot by that Company for their information. First, then, in regard to the expense of manufacturing coal gas, this, as may be expected, will vary with the price and quality of the coal, and also with the skill and economy in managing the different processes of the manufacture. In Glasgow, the cost of manufacturing 1000 cubic feet of coal gas is so low as 4*s.* 9*d.* exclusive of interest on capital. In Edinburgh it is from 7*s.* to 8*s.* In Liverpool and London about 10*s.* But the selling price of the gas in these different places is exactly in proportion to the price of producing it. In Glasgow, 1000 feet of gas sells at 8*s.* 6*d.*, in Edinburgh at 12*s.*, in Liverpool at 13*s.* 9*d.*, and in London at 14*s.* 6*d.* or 15*s.* The difference arises partly from differences in the dividends paid by the companies on their respective capitals, and partly, also, we believe, from waste, and perhaps part of the current expenses not being included in the cost price.

But even the quality of the gas in different establishments varies considerably in its illuminating power, owing partly to management, but chiefly to the nature of the coal from which it is generated. In this respect the gas from cannel coal, from which most of it is got in Scotland, is decidedly superior to the London gas, which is all produced from Newcastle coal; a cubic foot of the former will burn from one to one and a half times longer than one of the latter, and give all the time the same degree of light. On this account, therefore, the fair illuminating value of the gas in the above places does not correspond with its selling price, the London gas being really from one to one and a half times dearer. This consideration is of essential importance in all our inquiries into the economy of gases, and a want of due attention to it is one of the chief causes of those discrepant results which have been obtained on this subject, and of that diversity of opinion to which they have given rise.

In regard now to the price of manufacturing and selling oil gas, this is pretty much the same in different places, and the gas being all generated from the same material, its quality is hence pretty uniform. The cost of manufacturing 1000 cubic feet of oil gas is estimated by Taylor and Martineau, the patentees, at 26*s.*; by Mr. Peckstone at 28*s.*; by Mr. Ricardo, of the Bow Works, at 27*s.*; and it is actually made at Hull for 28*s.*; and at Leith, we believe, much the same. The selling price again is in London 50*s.*; in Hull 50*s.*; in Leith 50*s.*, until of late it has been reduced to 40*s.*, the lowest price at which it has ever been sold. But there is one important circumstance to be noticed here. At the above prices of the coal gas, all the Companies have been dividing considerable profits, which may be averaged at 8 per cent. on the capital of each, while the Oil Gas Companies again, at their prices, have been in many cases losing, and in no case dividing more than 2½ or 3 per cent.* It thus appears, then, that the same quantity of gas which, in the case of coal, sells in Glasgow at 8*s.* 6*d.*, in Edinburgh at 12*s.*, and in London at 14*s.* 6*d.*, cannot, in the case of oil, be any where sold with a profit under, we may safely say, 45*s.*, supposing even the oil to continue at the same rate to which it has fallen of late years.

But the quality of the oil gas is much superior to that even of the best coal in its light-giving power. A cubic foot of it will burn with an equal degree of light between three and four times longer than the London gas, and between two and three times longer than the Scotch gas.† If we take this circumstance into account, then, we shall obtain an exact estimate of the comparative economy of the two gases; 1000 feet of oil gas will thus give the same quantity of light as 3500 feet of London gas, and as 2500 feet of Scotch gas; and the prices of the same quantity of light derived from these different gases respectively will be,—from oil gas, 45*s.*, London coal gas, 60*s.* 9*d.*, Edinburgh coal gas, 30*s.*, Glasgow coal gas, 21*s.* 3*d.* The expense of the same light for tallow candles, at 1*s.* per lb., is about 80*s.* Of all these places, then, London is the most likely for an oil gas work to succeed as a profitable concern, Edinburgh next, and Glasgow the least. It appears evident, however, from these facts, that even in Edinburgh we cannot expect to obtain our light from oil gas at a price less than 50 per cent. higher than from coal, even though the price of oil should continue as it is. Considering indeed the waste which takes place in converting oil into gas, together with the expense of the process, it cannot be expected that the latter should ever form a very cheap light. In the present state of the manufacture, a quantity of the inflammable matter of the oil is lost by the imperfect nature of the decomposition, besides a quantity of the gas itself, which is necessarily wasted in every gas establishment. Of the amount of these losses we are not informed, but a loss there certainly is to some extent. Moreover, were there no expense attending the manufacture of oil gas, its light could not be so cheap as that from the oil itself, burned in a good lamp, where all the inflammable matter is consumed; and when we add to this all the expenses of the manufacture and gas establishment, it is evident, that the cost of this light must be considerably increased, unless the oil acquires by its conversion into gas some new illuminating virtue which it does not possess in its raw state, a circumstance which has indeed been asserted, but never proved.*

---

* The Whitechapel Road Oil Gas Company, according to Mr. Tait's information in the Dundee Report, divided, at the end of the first year, 2½ per cent.; but at the last general meeting (November, 1823,) no dividend was made. The Hull Company, by the same report, has paid nothing; the Norwich nothing, and the Colchester has been converted into a coal gas.

† Although the exact proportion of the illuminating powers of these gases has not yet been settled, a good many experiments have been made with this view; these, when rightly considered, do not differ from each other so much as has been supposed, and agree, on the whole, pretty nearly in assigning the above ratio of between two and four to one in favour of oil, according to the quality of the coal gas. The subject has not certainly been examined with sufficient attention, nor with any thing like that degree of accuracy which such experiments demand, and in the present state of science, easily admit of, and we are surprised that some of the parties interested have not already set on foot such inquiries as will set this matter completely at rest. Professor Leslie, we understand, has been recently engaged in making some experiments on these gases; and certainly no instrument is so well adapted for comparing their illuminating powers as the photometer, with which he has contrived to measure the various shades of light. Under the hands of skilful observers, this instrument could not fail to lead to interesting results. The method of shadows, however, is not entirely so satisfactory, nor in many respects so convenient, because we cannot easily compare, in this manner, the gases of different places unless they are actually brought together, and burned in the same apartment, whereas the photometer measures the actual as well as the relative degrees of light. Still, however, the method of shadows, with attention, and in the same place, will give a pretty near approximation to the truth; and we shall just state the results obtained in this manner by different observers. In London, Messrs. Taylor and Martineau find the illuminating powers of their oil gas 3½ times superior to that of the coal gas in the neighbourhood. This estimate has been confirmed by Mr. Brande, and several other observers, more particularly by Mr. Dewey of New York, in an experiment conducted with great fairness, each foot of the oil gas burning exactly three and a half times longer than a foot of the coal. Hence, it has been laid down at once as a general rule, that oil gas is three or four times superior to coal in illuminating powers, and this notion, sanctioned by the names of the observers and the accuracy of the experiments, and propagated with zeal by the oil gas advocates and companies, has had considerable weight with the public; the Committee of the Dundee Company, for example, having hence calculated on the illuminating powers as 3 to 1. But we believe it is undeniable, that the London gas obtained from Newcastle coal is considerably inferior to the Scotch gas obtained from the cannel coal and other Scotch coals. The exact proportion we do not know, but it is between 1 and 1½ times inferior—say, then, that it is only 1¼ times, and this, in the case of the Scotch gas, will reduce the estimate of Taylor and Martineau, the oil gas patentees themselves, to the proportion of 2⅘ to 1 in favour of oil; and this corresponds pretty nearly with the observations which have actually been made in this country. Mr. Crichton of Glasgow, late civil engineer there, makes the proportion 2 to 1 in favour of oil. Dr. Ure of Glasgow, finds the same proportion; and Mr. Milne, one of the agents for the oil gas patentees, according to a writer in the Dundee Report, makes it, in reference to the Glasgow coal gas, as 2, or, at most 2¼ to 1. Experiments, we believe, have also been made by the Company here on the

Such being the comparative economy of the two gases, let us now consider their respective qualities. On this point it is agreed on all hands that the oil is superior. In the first place, it is free from that sulphureous matter which rises along with the coal gas, from which it is difficult to deprive this latter gas, and the effect of which is not only to corrode the pipes, and all the internal fittings of the apparatus exposed to the gas, but also to tarnish the plate and gilding of the apartment in which the gas is burned. From this contamination the oil gas is entirely free, and this constitutes its great advantage. But, on the other hand, it cannot be denied that the plans which have been devised for purifying the coal gas have had considerable success. In Glasgow, and even in Edinburgh, where the coal is of inferior quality, the gas is now manufactured in such purity, that the presence of sulphur cannot be detected in it by the most delicate tests; and in fact it is said by these companies to be now incapable of tinging either plate or gilding any more than oil gas.† If this fact could be satisfactorily established, it would be of great importance. The best proof of it which could be given would be the adopting of the coal gas by jewellers, among whom its use was discontinued at the first trial, on account of its injurious effects, and has since, we believe, not been resumed by any of them. Another advantage ascribed to the oil gas is its freedom from any unpleasant smell. If this be meant of the gas itself as it escapes from the pipes by leakage or otherwise, the oil gas is in this respect certainly very little, if at all, superior to coal. We are convinced, indeed, from experience, that neither of them could well be tolerated, if allowed to escape unburnt; and it would be difficult to decide which of the two smells is the most offensive. But with proper attention on the part of the company, the escape of the gas can be entirely prevented, as is remarked by Mr. Tait, engineer, London, in his Report to the Dundee Company. "As to the smell of oil gas," says he, "being less offensive in rooms than coal gas, this is a mere matter of taste. For my own part, I would sooner tolerate the latter; but neither of them produce any smell whatever, if the services are secured, and the joints properly cemented." But if the smell refers to the effect on the air of the room by the burning of the gases, to the heat and closeness, to the smokiness, or to any other disagreeable vapour arising from any of the gases more than another—in this respect the oil certainly has the advantage. Much depends on the way in which the burners are managed, a proper attention to which will, perhaps, in either case, prevent any unpleasant effects. But on this point we have no satisfactory information.

"Oil gas," say Taylor and Martineau, "burns with a far purer and more brilliant light than coal gas." With good coal gas we cannot say that we have ever perceived a very material difference in this respect. Besides these, there are various minor points of comparison between the two gases, on which, however, it is unnecessary to enlarge; and in regard to the advantage which oil gas possesses, of being more easily generated, and without any of those nuisances to which the coal gas establishments are subject, also its being less bulky, and held therefore in gasometers, and distributed in pipes of half the usual dimensions, these advantages are all involved in the price.

Such, then, are a few of the facts regarding these two species of light, which we have endeavoured to collect, from different sources, for the information of our readers. It is evident, on the whole, that the oil gas, though it will be a much cheaper light than candles, will yet here be considerably dearer than coal gas; but then it is purer, and burns with a brighter light; and, as Mr. Dewey of New York remarks, if some are content with *fine*, there is no reason why others should not prefer *superfine*. This, of course, is a matter of choice with the public; and it is not our intention, by the above remarks, to recommend either the one or the other light in preference, but merely to state the facts which have come to our knowledge.—*Cal. Mercury.*

GASKET, a sort of plaited cord fastened to the sail-yards of a ship, and used to furl or tie up the sail firmly to the yard by wrapping it round both, six or seven times, the turns being at a competent distance from each other.

Bunt GASKET, is that which supports or ties up the bunt of the sail, and should consequently be the strongest, as having the greatest weight to support; it is sometimes made in a peculiar manner.

Quarter GASKET, used only for large sails, and is fastened about half-way out upon the yard, which part is called the quarter.

The Yard-arm GASKET, is made fast to the yard-arm, and serves to bind the sail as far as the quarter-gasket on large yards, but extends quite into the bunt of small sails.

GASSENDI, PETER, a celebrated French philosopher and astronomer, was born in a village in Provence, in 1592. He very early discovered great talents, and at the age of 16 was made professor of rhetoric at Digne, and soon after professor of philosophy at Aix. Gassendi died in 1655, in the 63d year of his age, leaving his manuscripts to M. de Monmor, his friend and executor.

Edinburgh gas, which is generated from different sorts of coal, and for gas of an average quality, the proportion has been found as 2¼ to 1. Besides these authorities, an interesting set of experiments have been made by Messrs. Heropath and Rootsey on the Bristol gas, and their proportion is that of 2¼ to 1, or 2 to 1. Making due allowance, then, for the bias of the respective parties, we are certainly not underrating the oil gas when we assume it, as above, at 2½ times superior to coal gas.

* Sir W. Congreve observes, that "there can be no doubt that the light thus produced by oil gas is much cheaper than that produced by the direct burning of the oil, and some have even estimated the gain at 25 per cent. It would require, however, strong proof to substantiate this fact, and the experiments of Heropath and Rootsey of Bristol shew, on the contrary, a loss of 28 per cent.

† Mr. Neilson, engineer, Glasgow, in his judicious Report to the Dundee Company, observes, "the gas at present made in the Glasgow works seems to be entirely free of it, (the sulphuretted hydrogen,) and will not tinge either silver or gilding, nor can the acetate of lead, which is reckoned a delicate test, discover in it any of this offensive mixture." Besides the sulphuretted hydrogen, however, the gas contains hydro-sulphuret of ammonia, which proves injurious to copper and iron gas-pipes, and of which it is still more difficult to deprive the gas. Mr. Dewey of New York states, that this has been done by Mr. James Neilson of the Glasgow gas works, but that "owing to the expense of the process, and the low price at which the gas is furnished to the customers, it has not been carried fully into effect." Great improvements, therefore, may yet be looked for in the purification of coal gas, the manufacture of which presents a rich and interesting field for the researches of the chemist.

GASTEROSTEUS, the *Stickle Back*, in Natural History, a genus of fishes of the order of thoracici. There are thirteen species, G. aculeatus, or three-spined stickle-back, is found in almost all the fresh waters of Europe, and is about three inches long, and in the beginning of the summer displays the most beautiful combination of bright-red, fine olive-green, and silvery whiteness. It is extremely active and rapid, and is particularly injurious in fishponds, as it devours the spawn of the fish.

GASTRIC Juice, a fluid of the utmost importance in the process of digestion. It does not act indiscriminately on all substances, nor is it the same in all animals, nor does it continue always of the same nature, even in the same animal, changing according to circumstances; it acts with a chemical energy in dissolving food; attacking the surface of bodies, and uniting to the particles of them. It operates with more energy and rapidity the more the food is divided, and its action is increased by a warm temperature. The food is not merely reduced to very minute parts; its taste and smell are quite changed; its sensible properties are destroyed; and it acquires new and very different ones. This fluid does not act as a ferment, it is a powerful antiseptic, and even restores flesh already putrefied.

GASTROBRANCHIUS, in Natural History, a genus of fishes of the order cartilaginei. It is characterized by the circumstance of exhibiting no traces of the existence of such an organ as the eye. It will often enter the mouths of fishes fixed on the hook of the angler, and gnaw a passage through their bodies, devouring all but the bones and skin. Its substance is so highly glutinous, that a large vessel of sea water will, in a short time after the living cœcus is placed in it, become of the consistence of a jelly.

GATE, in Architecture, a large door, leading or giving entrance into a city, town, castle, palace, or other considerable building; or a place giving passage to persons, horses, coaches, or waggons, &c.

GATT, is the same as Channel, and is a term constantly used on the Flemish coast and in the Baltic for that purpose.

GAUGER, a king's officer appointed to examine all tuns, pipes, hogsheads, and barrels, of wine, beer, ale, oil, honey, &c. and give them a mark of allowance before they are sold in any place within the extent of his office.

GAUGE Point of a solid, is used to denote the diameter of that circle, whose area is expressed by the same number as is equal to the number of cubic inches in the solid. Thus 17·15 being the diameter of a circle whose area is 231; this is called the gauge point of the wine gallon, which contains 231 cubic inches.

GAUGING, the art or act of measuring the capacities of all kinds of vessels, and thence ascertaining the quantity of liquor which they contain. Gauging forms a part of mensuration, and is treated of by most authors who have written on the latter subject; this, however, is generally with reference to regular figures, as the frustums of cones and conoids, of parabolic, hyperbolic, and elliptic spindles, &c. But as casks are seldom of any exact forms, these rules must be regarded as merely theoretical, and not applicable to the common cases that occur in practice. To remedy the inconvenience arising from such a number of rules, and at the same time to abridge the labour attendant on several of them, we will give one general rule for all cases, exceedingly simple in its application, and which is as follows: Add into one sum,

39 times the square of the bung diameter,
25 times the square of the head diameter, and
26 times the product of those diameters;

multiply the sum by the length of the cask, and divide the product by 114; then this last quotient divided by 231 will give the wine gallons, and divided by 282 will give the ale gallons.

Or, $(39\ B^2 + 25\ H^2 + 26\ BH) \times \frac{L}{114}$ is the content in inches; which being divided by 231 for wine gallons, or by 282 for ale gallons, will be the content.

Exam. Let the length of a cask be 40 inches, the bung diameter 32, and the head diameter 24.

Here .... $32^2 \times 39 = 39936$
and .... $24^2 \times 25 = 14400$
and .... $32 \times 24 \times 26 = 19968$

the sum 74304
multiplied by 40

and divide by .... 114)2972160

gives .... 26071 cub. in.

this divided by 231 gives 112 wine gallons, or divided by 282 gives 92 ale gallons.

But the common practice of gauging is performed mechanically, by means of the gauging or diagonal rod, or the gauging sliding rule, the description and use of which are as follow.

Gauging, or *Diagonal Rod*, is a rod or rule adapted for determining the contents of casks, by measuring the diagonal only, *viz.* the diagonal from the bung to the extremity of the opposite stave next the head. It is a square rule, having four sides or faces, being usually four feet long, and folding together by means of joints. Upon one face of the rule is a scale of inches, for taking the measure of the diagonal; to these are adapted the areas, in ale gallons, of circles to the corresponding diameters, like the lines on the under sides of the three slides in the sliding rule, described below. And upon the opposite face are two scales, of ale and wine gallons, expressing the contents of casks having the corresponding diagonals; and these are the lines which chiefly constitute the difference between this instrument and the sliding rule; for all the other lines upon it are the same with those in that instrument, and are to be used in the same manner.

To use the Diagonal Rod. Unfold the rod, and put it in at the bung-hole of the cask to be gauged, till its end arrive at the farthest possible distance from the bung-hole, and note the inches and parts cut by the middle of the bung; draw out the rod, and look for the same inches and parts on the opposite face of it, and annexed to them are found the contents of the cask, both in ale and wine gallons.

Exam. Let it be required to find, by this rod, the content of a cask whose diagonal measures 34·4 inches; which answers to the cask in the foregoing example, whose head and bung diameters are 32 and 24, and length 40 inches; for if to the square of 20, half the length, be added the square of 28, half the sum of the diameters, the square root of the sum will be 34.4 nearly. Now, to this diagonal 34·4 corresponds upon the rule, the content 91 ale gallons, or, 111 wine gallons; being but one less than the content found by the former general rule above given.

The **Gauging** *Rule*, or *Sliding Rule*, is a sliding rule particularly adapted to the purposes of gauging. It is a square rule, of four faces or sides, three of which are furnished with sliding pieces running in grooves. The lines upon them are mostly logarithmic ones, or distances which are proportional to the logarithms of the numbers placed at their ends; which were fine lines placed upon rulers, by Gunter, for expeditiously performing arithmetical operations, using a pair of compasses for taking off and applying the several logarithmic distances; but instead of the compasses, sliding pieces were added, by Mr. Thomas Everard, as more certain and convenient in practice, from whom this sliding rule is often called Everard's Rule.

GAURS, an ancient sect of the Magicians in Persia, who profess the worship of one God alone, the belief of a resurrection and a future judgment, and utterly detest all idolatry. They perform their worship before fire, for which they have an extraordinary veneration, as believing it to be the most perfect emblem of the Deity.

GAUT, a term made use of in the East Indies, to denote a passage or road from the coast to the mountainous or upland country.

GAUZE, in Commerce, a thin transparent stuff, sometimes woven with silk, and sometimes only of thread, either plain or figured; the latter being sometimes worked with flowers of silver or gold on a silk ground.

GAVELKIND, a tenure or custom in Kent, by which the lands of the father are, at his death, equally divided amongst all his sons; or the land of a deceased brother, in case he leaves no issue, among all his brethren. This custom came from our Saxon ancestors. The customs attending this tenure are, that the heir, at the age of fifteen, may give or sell his lands in gavelkind; and though the father is attainted of treason, and suffers death, the son inherits. A wife shall be endowed of a moiety of the gavelkind lands, of which her husband died seised, during her widowhood. Likewise a husband may be tenant by courtesy of half his wife's lands, without having any issue by her; but if he marries again, not having issue, he forfeits his tenantcy.

GAZETTE, a printed account of the transactions of all the countries in the known world, in a loose sheet or half sheet. This name is with us confined to that paper of news published by authority of the government. The first gazette in England was published at Oxford, Nov. 7, 1665.

GELATINE, in Chemistry, is one of the constituent parts of animal substances, and may be obtained by repeatedly washing the fresh skin of an animal in cold water, afterwards boiling it, and reducing it to a small quantity by slow evaporation, and allowing it to cool. It then assumes the form of jelly, and becomes hard and semitransparent. It is a principal part both of the solid and fluid parts of animals, and is employed in the state of glue, size, and isinglass.

GELD, in our old customs, a Saxon word, signifying money or tribute; also a compensation for a crime. Hence wergeld was used for the value of a man slain, and orsgeld, of a beast.

GELLIBRAND, Henry, an English astronomer, having been professor of that science in Gresham College, was born in London 1597, and died in the same city of a fever in 1636, being only 39 years of age. Gellibrand was an intimate acquaintance of Briggs, and wrote the preface, and attended to the publication, of the "Trigonometria Britannica," Briggs having died before the completion of that great undertaking.

GEMINI, the Twins, ♊. One of the Northern signs, being the third sign of the zodiac, and the last of the Spring signs. According to the fixed zodiac of Hipparchus, the Sun enters Gemini on the 21st of May. That is to say, the Earth, at that time, passes into the sign Sagittarius, and the Sun, as seen from the Earth, appears to have made his transit from Taurus into Gemini. According, however, to the recession of the equinoxes, the Sun enters Gemini on the 18th of June. The Earth is of consequence about to quit Sagittarius, and enter Capricornus. A still larger portion of the North Pole is now in the light than we observed in the last sign, and the days have proportionally increased in length, for the Sun rises at IV ho. 6 mi. A. M., and sets at VII ho. 51 mi. P. M. By doubling the time of his rising, we get the length of the night 8 ho. 12 mi., and by doubling the time of his setting, the length of the day is 15 hours 48 minutes.

Boundaries and Contents.—Gemini are bounded on the N. by Lynx, E. by Cancer, S. by Monoceros and Canis Minor, and W. by Taurus. There are 85 stars in this constellation; namely, two of the 2d magnitude, four of the 3d, six of the 4th, &c. The chief star is Castor, whose right ascension is 110° 46′ 25″, and its declination 32° 16′ 6″. This star appears on the N. N. E. ¾ E. point of the compass, at London, and it rises and culminates as in the following Table: Merid. Alt. 70° 45′ 6″.

Month.	Rises.	Culm.	Month.	Rises.	Culm.
	ho. mi.	ho. mi.		ho. mi.	ho. mi.
Jan.	2 55 A.	12 31 M.	July	3 0 M.	12 43 A.
Feb.	12 45 A.	10 23 A.	Aug.	12 55 M.	10 35 M.
Mar.	10 55 M.	8 34 A.	Sept.	11 0 A.	8 38 M.
April	8 55 M.	6 41 A.	Oct.	9 10 A.	6 52 M.
May	7 0 M.	4 50 A.	Nov.	7 15 A.	4 55 M.
June	5 0 M.	2 47 A.	Dec.	5 10 A.	2 50 M.

Castor passes vertical over the States of Barbary, Palestine, Persia, Cashmere, Thibet, Honan in China, Japan, Louisiana in North America, the southern parts of the United States, the Bermudas, &c. When Castor begins to rise, the club of Orion, and after it the star Betelgeux, appear; but by this time Pollux is fairly above the horizon. At the time those stars begin to rise on the N. E. by N. point of the horizon, Cepheus, Cygnus, and Lacerta, are in the zenith. Serpentarius declines in the W., leading with him Taurus Poniatowski. Procyon rises when Cassiopeia and Andromeda are in the zenith, and Canes Venatici in the Northern horizon. When Castor and Pollux come to the meridian, Canis Major appears in the Southern, Lyra and Cygnus in the Northern, Virgo in the Eastern horizon, and the Lynx occupies the zenith. Between the meridian and the E. we find Cancer and Leo; between the meridian and the W. Taurus and Aries; and between the zenith and the S. Canis Minor and the Unicorn.

GEMMA, in Botany, a bud, a compendium of a plant seated upon the stem and branches, and covered with scales, to defend the tender rudiments from cold and external injuries, till their parts being unfolded, they acquire strength, and render any further protection unnecessary. In general, we may distinguish three kinds of buds; that containing the flower, that containing leaves, and that containing both flower and leaves. *See* Botany and Plants.

GEMS, or Precious Stones, are sometimes found of regular shapes, and with a natural polish; and sometimes of irregular shapes, and with a rough coat. The first sort may be considered as of the pebble kind, and are said to be found near the beds of rivers, after great rains; the others are found in mines, and in the clefts of rocks. The gems of the first sort were what the ancients most usually engraved upon; these are commonly called intaglios; and they are mostly of a long oval figure, inclining to a point at each end, convex as well on the engraved face as on the others, with a ridge running from end to end on the under side, which is hereby, as it were, divided into two faces; both which are also, though not so distinctly, parted from the upper face, by another ridge running quite round the oval.

The stone most commonly found engraved is the beryl. The next is the emerald; and then the jacinth. The chrysolite is but rarely found engraved; as are also the crystal, or oriental pebble, the garnet, and the amethyst. Of the beryl there are three species; the red, inclining to orange colour, transparent and lively; the yellow, of an ochre colour, and the white, commonly called the chalcedony, and the colour of sheer milk. These two last have less life than the first. The emerald is green, nearly of the colour of stagnated water; sometimes tolerably clear, but for the most part full of black and white specks. The jacinth is of a deep tawny red, like very old Port wine, but lively and transparent. The chrysolite is of a light green grass colour, and is supposed to have been the beryl of the ancients, transparent, but not lively. The crystal or oriental pebble is harder and more lively than the common rock crystal; is of a silvery hue, and but very little inferior to the white sapphire. The garnet is of the same colour as the jacinth, but more inclining to the purple, and not so lively. The amethyst is of a deep purple, transparent and lively.

The following is a general table of what are usually called precious stones:—The beryl, red, yellow, or white; emerald, green; jacinth, of a deep tawny red; chrysolite, of a light grass-green; crystal, or oriental pebble, of a silvery white; garnet, of a deep red claret colour; amethyst, purple; diamond, white; ruby, red or crimson coloured; emerald, of a deep green; aqua marina, of a bluish sea green, like sea water; topaz, of a ripe citron yellow; sapphire, of a deep sky blue, or of a silver white; cornelian, red or white; opal, white and changeable; vermilion stone, more tawny than the jacinth.

All these stones are more or less transparent: the following are all opaque:—The cat's eye, brown; red jasper, called also thick cornelian, of the colour of red ochre; jet, black; agates, of various sorts; blood-stone, green, veined or spotted with red and white; onyx, consisting of different parallel strata, mostly white and black; sardonyx, of several shades of brown and white; agate-onyx, of two or more strata of white, either opaque or transparent; alabaster, different strata of white and yellow, like the agate-onyx, but all opaque; toad's eye, black; turquoise, of a yellowish blue inclining to green; lapis lazuli, of a fine deep blue.

Of most of the species beforementioned, there are some of an inferior class and beauty. These are commonly called by jewellers occidental stones; they are mostly the produce of Europe, and found in mines or stone quarries; and are so named in opposition to those of a higher class, which are always accounted oriental, and supposed to be only produced in the East. The onyx, sardonyx, agate-onyx, alabaster of two colours or strata, as also certain shells of different coats, were frequently engraved by the ancients in relief; and these sorts of engravings are commonly called cameos. They also sometimes ingrafted a head, or some other figure in relief, of gold, upon a blood stone.

Besides which there are some antiques, mostly cornelians, that are covered with a stratum of white. This stratum has by some been looked upon as natural; but it was really a sort of coat of enamel that was laid on The stones esteemed the best for engraving upon, were the onyx and sardonyx; and next to them, the beryl and the jacinth. The ancients engraved most of their stones, except the onyx and the sardonyx, just as they were found; their natural polish excelling all that can be done by art; but the beauty of the several species of onyx could only be discovered by cutting.

The merit of intaglios and cameos depends on their erudition, as it is termed, or the goodness of the workmanship, and the beauty of their polish. The antique Greek gems are most esteemed; and next to them the Roman ones, in the times of the higher empire. Lapidaries employ a considerable quantity of diamond in powder, which they use with steel instruments, to divide pebbles and precious stones. The small pieces of diamond of which the powder is made, are worth twenty-eight shillings a carat. The use of the diamond in this way is very extensive. Had nature withheld the diamond, the pebble, the agate, and a variety of other stones, would have been of little value, as no other substance is hard enough to operate upon them. In this way rock crystal from Brazil is divided into leaves, and ground and polished with diamond dust for spectacles, and other optical instruments.

Gems, *Imitation of Antique*, a method of taking the impressions and figures of antique gems, with their engravings, in glass of the colour of the original gem. The great care in the operation is, to take the impression of the gem in a very fine earth, and to press down upon this a piece of proper glass, softened or half melted at the fire, so that the figures of the impression made in the earth may be nicely and perfectly expressed upon the glass. The yellowish tripoli has been found best adapted for this purpose.

GENDARMES, or Gens d'Armes, in the French armies, a denomination given to a select body of horse, on account of their succeeding the ancient gendarmes, who were thus called from their being completely clothed in armour. The appellation is now bestowed on both the horse and foot soldiers in France, who are employed in the police of the country. They are chosen from all the rest of the army on account of their good behaviour, and enjoy superior pay and advantages.

GENDER, among Grammarians, a division of nouns or names to distinguish the two sexes.

GENEALOGICA Arbor, or *Tree of Consanguinity*, signifies genealogy or lineage drawn out under the figure of a tree, with its root, stock, branches, &c. The genealogical degrees are usually represented in circles ranged over, under, and aside each other.

GENEALOGY, an enumeration of a series of ancestors; or a summary account of the relations and alliances of a person or family.

GENERAL Issue, in Law, is that plea which traverses and denies at once the whole declaration or indictment, without offering any special matter, by which to evade it: it is called the general issue, because, by importing an absolute and general denial of what is alleged in the declaration, it amounts at once to an issue, or fact affirmed on one side, and denied on the other. This is the ordinary plea upon which most causes are tried, and is now almost invariably used in all criminal cases. It puts every thing in issue, that is, denies every thing, and requires the party to prove all that he has stated. It is a frequent question, what can be given in evidence by the defendant upon this plea, and the difficulty is, to know when the matter of defence may be urged upon the general issue, or must be specially pleaded upon the record. In many cases, for the protection of justices, constables, excise officers, &c. they are by act of parliament enabled to plead the general issue, and give the special matter for their justification under the act in evidence.

General *of an Army*, in the art of war, he who commands in chief. The office of the general is to regulate the march and encampment of the army; in the day of battle to choose out the most advantageous ground; to make the disposition of the army; to post the artillery; and where there is occasion, to send his orders by his aides-de-camp. At a siege he is to cause the place to be invested; to order the approaches and attacks; to visit the works, and to send out detachments to secure his convoys.

General *of Horse*, and *General of Foot*, are posts next under the general of the army. *General of the Artillery*, has the charge of the ordnance. *General*, is also used for a particular march or beat of drum, being the first which gives notice for the infantry to be in readiness to march. *General*, is also used for the chief of an order of monks.

General *Terms*, among Logicians, are those made the signs of general ideas.

GENERANT, or Genitum, that which is generated, or supposed to be generated, by the motion of any point, line, or figure. The generant is always one dimension higher than the generating quantity; thus a line is generated by the motion of a point, a surface by a line, and a solid by a surface. It is generally a theorem in geometry, that the measure of any generant is always equal to the product of the generating quantity, drawn into the path of the centre of gravity of the latter, whether its motion be rectilineal or rotatory. So also,

GENERATED, is used by mathematicians to denote whatever is formed by the motion of a point, line, or surface; thus a line is said to be generated by the motion of a point, a surface by the motion of a line, and a solid by the motion of a surface. The same term is also sometimes used in a similar sense in arithmetic and algebra; thus 20 is said to be generated by the two factors 4 and 5, or 2 and 10; ab of the factors, a and b, &c.

GENERATING Line or Figure, in Geometry, is that line or figure, by the motion of which another figure or solid is supposed to be described or generated. In the fluxional analysis all kinds of quantities are supposed to be generated by the motion of other quantities, and the quantities thus generated are termed fluents.

GENERATION, in Mathematics, denotes the formation or description of any geometrical figure or magnitude by the motion of another quantity or magnitude, of a dimension one degree less.

GENERICAL Name, in Natural History, the word used to signify all species of natural bodies, which agree in certain essential and peculiar characters, and are therefore all of the same family or kind, so that the word used as the generical name, equally expresses every one of them, and some other words expressive of the peculiar qualities of figures of each are added, in order to denote them singly, and make up what is called the specific name. Thus the word *rosa* or rose, is the generical name of the whole series of flowers of that kind, which are distinguished by the specific names of the red-rose, the white-rose, the apple-rose, &c.

GENESIS, in Mathematics, is nearly the same as generation, being the formation of a line, surface, or solid, by the flowing of a point, line, or surface. Here the moving line or figure is called the *describent*, and the line in which the motion is made the dirigent.

GENEVA, Gin, a hot fiery spirit, too much used by the lower classes of people in this country, as a dram, and most injurious to their constitution and morals. A liquid of this kind was formerly sold in the apothecaries' shops, drawn from the juniper-berry, but the liquor now sold under the name of geneva or gin, is composed of oil of turpentine and malt spirits. The Holland's geneva is manufactured chiefly at Schiedam, near Rotterdam, from wheat and juniper-berries.

GENIUS, in matters of Literature, &c. a natural talent or disposition to do one thing more than another; or the aptitude a man has received from nature to perform well and easily that which others can do but indifferently, and with a great deal of pains.

GENTIANA, in Botany, a genus of the pentandria digynia class and order. Natural order of rotaceæ. Gentianæ Jussieu. There are fifty-three species. The most remarkable is the lutea or common gentian, the root of which is an excellent stomachic bitter.

GENUS, among Metaphysicians and Logicians, denotes a number of beings which agree in certain general properties common to them all.

Genus, in Natural History, a subdivision of any class or order of natural beings, whether of the animal, vegetable, or mineral kingdoms, all agreeing in certain common characters.

GEOCENTRIC *Latitude of a Planet*, is its distance from the ecliptic as it is seen from the earth.

Geocentric *Place of a Planet*, the place wherein it appears to us from the earth, supposing the eye there fixed.

GEOGRAPHY, is the science which describes the surface of the earth; its various kingdoms, states, and empires; the rivers by which they are intersected, their mountains, woods, &c. The several kingdoms and states of the world we have already described under the respective words, Africa, America, Asia, and Europe. We will, therefore, in this article, treat very briefly of the natural divisions of the earth, and what is properly termed physical geography.

Geography assigns to the earth the following grand divisions: —Europe, Asia, Africa, America, Australasia, or New Holland.

Of the grand divisions of the earth, Asia has ever been esteemed the most populous; and is supposed to contain five hundred millions of souls, if China, as has been averred by the latest writers, comprises three hundred and thirty millions. The population of Africa may be estimated at thirty millions, of America at twenty millions, and one hundred and fifty millions may perhaps be assigned to Europe.

Modern discoveries have evinced that more than two thirds of the globe is covered with water, which is contained in hollow spaces, or concavities, more or less large. But the chief convexities or protuberances of the globe consist of elevated uplands, sometimes crowned by mountains, sometimes rather level, as the extensive protuberance of Asia. In either case, long chains of mountains commonly proceed from those chief convexities in various directions, and the principal rivers usually spring from the most elevated grounds.

The grandest concavity of this globe is filled by the Pacific Ocean, occupying nearly half its surface, from the eastern shores of New Holland to the western coast of America, and diversified with several groups of islands, which seem in a manner the summits of vast mountains emerging from the waves. This ocean receives but few rivers, the chief being the Amur from Tartary, the Hoan Ho and Kian Ku from China, while the principal rivers of America run towards the east.

Next to this in magnitude is the Atlantic, between the Old and New Continents; and the third is the Indian Ocean. The seas between the arctic and the antarctic circles and the poles, have been sometimes styled the Arctic and Antarctic Oceans; but the latter is only a continuation of the Pacific, Atlantic, and Indian Oceans; while the Arctic Sea is partly embraced by continents, and receives many important rivers. Besides these, there are other seas more minute, as the Mediterranean, the Baltic, and others still smaller, till we come by due gradation to inland lakes of fresh water.

The courses of rivers are sometimes marked by oblong concavities, which generally at first intersect the higher grounds, till the declivity becomes more gentle on their approach to their inferior receptacles. But even large rivers are found sometimes to spring from lowland marshes, and wind through vast plains, unaccompanied by any concavity, except that of their immediate course; while on the other hand, extensive vales, and low hollow spaces, frequently occur destitute of any stream. Rivers will also sometimes force a passage where nature has erected mountains and rocks against it, and where the concavity would appear to be in another direction, which the river might have gained with more ease. In like manner, though the chief mountains of Europe extend in a southeasterly and north-westerly direction, yet there are so many exceptions, and such numerous and important variations in other parts of the globe, as to render any attempt at a general theory vain.

From the vast expanse of oceanic waters, arises in the ancient hemisphere that wide continent, which contains Asia, Europe, and Africa; and in the modern hemisphere the continent of America, which forms a kind of separate island, divided by a strait of the sea from the ancient continent. In the latter, many discoveries of great importance to geography are of a very recent date, and it is not above eighty years since we obtained an imperfect idea of the extent of Siberia and the Russian empire, nor above thirty-five since ample, real, and accurate knowledge of these wide regions began to be diffused. So that, in truth, America may be said to have been discovered by Europeans before many parts of Asia; and of Africa our knowledge continues imperfect, while the latest observations, instead of diminishing, rather increase our idea of its extent, at least in regard to its insular appendages.

But the grandest division of the ancient continent is Asia, the parent of nations, and of civilization: on the north-east and south, surrounded by the ocean; but on the west, divided by an ideal line from Africa; and from Europe by boundaries not very strongly impressed by the hand of nature. The Russian and Turkish empires, extending over large portions of both continents, intimately connect Asia with Europe. But for the sake of clearness and precision, geographers retain the strict division of the ancient continent into three parts, which, if not strictly natural, is ethical, as the manners of the Asiatic subjects of Russia, and even of Turkey, differ considerably from those of the European inhabitants of those empires.

Physical Geography.—The prevailing theories of the present day are the inventions of Professor Werner, of Freyburgh, and Dr. James Hutton, of Edinburgh; each of these has been ably supported and elucidated by the proofs, illustrations, and comparative views of acute and eloquent controversialists, and two sects have been formed, under the appellation of Wernerians and Huttonians. The first principle which the Wernerian theory assumes is, that our globe was once covered with a sort of chaotic compost, holding, either in solution or suspension, the various rocks and strata which now present themselves to us as its exterior crust. From some unexplained cause, this fluid began first to deposit those bodies which it held in chemical solution, and thus a variety of crystallized rocks were formed. In these we find no vegetable or animal remains, nor even any rounded pebbles; but in the strata, which lie upon the crystalline or first deposits, shells and fragments occasionally occur; these, therefore, have been termed *transition strata;* and it is imagined, that the peopling of the world commenced about this period. The waters upon the earth began now more rapidly to subside, and finely divided particles, chiefly resulting from disintegration of the first formations, were its chief contents;—these were deposited upon the transition rocks, chiefly in horizontal layers. They abound in organic remains, and are termed by Werner, *Floetz*, or *secondary rocks.*

It is now conceived, that the exposure of the *primitive transition* and *secondary* rocks to the agencies of the wind and weather, and to the turbulent state of the remaining ocean, produced inequalities of surface, and that the water retreated into low lands and valleys, where a further deposition took place, constituting clay, gravel, and other *alluvial* formations.

There are also certain substances which, instead of being found in regularly alternating layers over the earth, are met with in patches; as rock-salt, coal, basalt, and some other bodies which Werner hath called *subordinate* formations. Lastly, subterraneous fires have sometimes given birth to peculiar and very limited products; and these are called *volcanic* rocks. Such is Werner's account of the production of rocks, which he arranges under the terms *primary transition, secondary, alluvial, subordinate*, and *volcanic formations.*

Hutton, looking upon the face of nature, gives a very different account of the present order of things, and observes every thing in a state of decay; but as she has obviously provided for the regeneration of animal and vegetable tribes, the philosopher descries in this apparent destruction of the surface of the earth, the real source of its renovation. The stupendous mountains exposed to the action of the varying temperature of the atmosphere, and the waters of the clouds, are, by slow degrees, suffering constant diminution; their fragments are dislodged, masses are rolled into the valley, or carried by the rushing torrent into rivers; whence they are transported to the sea. The lower and softer rocks are undergoing similar, but more rapid destruction. The result of all this must be, the accumulation of new matter in the ocean, which will be deposited in horizontal layers. Hutton perceives the transition rocks of Werner, though not strictly crystalline, made up apparently of finely divided matter, more or less indurated; sometimes very hard in texture, and of a vitreous fracture; that this hardening is most perceptible when in contact with the primitive or inferior rock, which often pervades the transition rocks in veins, or appears to have broken up or luxated the superincumbent masses. The transition or secondary rocks of Werner were, according to Hutton, deposited at the bottom of the ocean, in consequence of operations similar to those which are now active, and the primary rocks were formed beneath them by the operation of subterraneous fires; their crystalline texture, their hardness, their shape and fracture, and the alterations they have produced upon their neighbours, are the proofs of the correctness of these views. It is by the action of fire then, that rocks have been elevated, that strata have been hardened, and that those changes have resulted, which an examination of the earth's surface unfolds. The production of soils, and of alluvial lands, is considered as dependent upon causes the same as those referred to in the other theory. Hutton refers to fire as well as water, for the production of our present rocks; the former consolidating, hardening, and elevating; the latter, collecting and depositing the strata.

GEOLOGY, is the doctrine of the earth in its insentient, or unorganized frame, or of those masses of rock, mountains, strata, minerals, &c. which compose the earth. The science of geology, independently of the healthy employment it affords, is of great importance in a practical point of view. It very nearly concerns the miner, engineer, and drainer, and even the farmer and architect; and discloses a variety of indications highly useful in their respective pursuits: to the miner, the rocks containing metallic veins and coals; to the engineer, the association of hard rocks with soft; to the drainer, the intersection of a country by hard dykes, or veins impermeable to water; to the farmer, the best places for finding lime-stone, marl, and clay; and to the architect, the most durable stones for building.

The stony masses of which the earth is composed, are numerous, and are found laid one above another, so that a rock of one kind of stone is covered by another species of rock, and this by a third, and so on. In this superposition of rocks, it has been observed, that their situation is by no means arbitrary; each occupies a determinate place, so that they follow one another in regular order from the deepest part of the earth's crust, which has been examined, to the very surface. Thus there are two things respecting rocks which claim our attention; namely, their composition, and their relative situation. But besides the rocks which constitute almost the whole of the earth's crust, there are masses to be considered traversing the rocks in a different direction, and known by the name of *veins*, as if the rocks had split asunder in different places from top to bottom, and the chasm had been afterwards filled up with the matter which constitutes the vein. It appears, therefore, that the subject naturally divides itself into three parts; 1. The structure of rocks; 2. The situation; and 3. Veins.

Of the Structure of Rocks.—Rocks may be divided into two classes: first, those composed of one mineral substance, and which are in reality simple rocks; secondly, we observe rocks that are compound, or *composed of more than one mineral substance.* Cemented; composed of grains agglutinated by a cement, as *sand-stone.* Others that are aggregated; composed of parts connected together without a cement, as granite.

The aggregated rocks are likewise of two kinds; namely, I. Indeterminate. Only one instance of this kind of aggregation has hitherto occurred, namely, in the *older serpentine*, where limestone and serpentine are so conjoined that it is difficult to say which predominates. II. Determinate, which are either 1. Single aggregated; or 2. Double aggregated.

There are four kinds of single aggregated rocks; namely, 1, Granular; composed of grains whose length, breadth, and thickness are nearly alike, and which are of contemporaneous formation; as *granite sienite.* 1. Slaty; composed of plates laid above each other; as *mica slate.* 3. Porphyritic; composed of a compact ground, containing in it crystals, which appear to have been deposited at the time the rock was formed; as *common porphyry.* 4. Amygdaloidal; composed of a compact ground, containing in it vesicles which appear to have been afterwards filled up; as *amygdaloid.*

There are five kinds of double aggregated rocks; namely, 1, Granular slaty; composed of slaty masses laid on each other. Every individual slate is composed of grains cohering together; or it is slaty in the great, and granular in the small; as *gneiss.* 2. Slaty granular; composed of large granular masses cohering together; each grain is composed of plates; or the rock is granular in the great, and slaty in the small; as *topaz rock.* 3. Granular porphyritic; granular in the small, and porphyritic in the great; as *granite, green-stone* frequently. 4. Slaty porphyritic, slaty in the small, porphyritic in the great, as *mica* slate. 5. Porphyritic and amygdaloidal, at the same time; as amygdaloid and basalt frequently.

Of the relative Situation of Rocks.—The rocky masses, amounting to about sixty, are variously placed over each other, and occupy determinate situations, limestone above granite, &c. The rocks which constitute the nucleus and even crust of the earth, are thus every where the same, in the same situations with respect to each other, and they may all be divided into five classes: 1. The nucleus mass, nearest the centre, or the basis of other formations. 2. Those which cover the first; the third covering the second, and so on. Therefore the first class, though covered by all the rest, never lie over any other class. These grand classes of rocks he has denominated *formations* and distinguished them by the following specific names. 1 Primitive formations. 2. Transition formations. 3. Floetz, or horizontal formations. 4. Alluvial formations. 5. Volcanic formations.

The primitive formations are the lowest of all, and the alluvial constitute the surface of the earth; for the volcanic are confined to particular points. Not that the primitive are always at a great depth, for very often they are at the surface, or even constitute mountains. In such cases, the other formations are wanting altogether. In like manner, the transition, and other classes, may each in its turn occupy the surface or constitute the mass of a mountain. In such cases, all the subsequent formations are wanting in that particular spot. Each of these grand classes of formations consist of a great or small number of rocks, which occupy a determinate position with respect to each other, and which, like the great formations themselves, may often be wanting in particular places.

Class 1. *Primitive Formations.* The rocks which constitute the primitive formations are numerous, and have been divided into seven sets, which constitute as many primitive formations. They are distinguished each by the name of that particular rock which constitutes the greatest proportion of the formation. And these seven sets of primitive formations are the following:

1. Granite,
2. Gneiss,
3. Mica slate,
4. Clay slate,
5. Newest primitive porphyry,
6. Sienite,
7. Newer serpentine.

The granite is the undermost, the sienite the uppermost, of the primitive formations. Granite is scarcely mixed with any other rock; but in gneiss, mica-slate, and clay-slate, there occur beds* of old porphyry, primitive trap, primitive limestone, old serpentine, quartz rock, which constitute formations subordinate to gneiss, mica-slate, and clay-slate. Gypsum is met with in beds of mica-slate, and old flint in clay-slate. These, therefore, are formations subordinate to mica and clay-slate. Thus, besides seven principal, there are seven subordinate formations, interspersed among the second, third, and fourth formations, to which we may add topaz rock, lying over gneiss and under clay-slate, so that the primitive formations amount in all to 15. Granite is the oldest, and alluvial the newest formations.

Class 2. *Transition Formations*, lying immediately over the primitive formations, consist only of 4 sets. 1. Gray-wacke; 2. transition lime-stone; 3. transition trap; 4. transition flint-slate; all which alternate with each other, except the limestone, which seems to rest upon the primitive formations.

It is in the transition rocks that petrifactions first make their appearance; and they always consist of species of corals and zoophytes, which do not at present exist, and which therefore we may suppose extinct. The vegetable petrifactions are likewise the lowest in that kingdom, such as fernes, &c. This remarkable circumstance has induced Werner to conclude, that the transition rocks were formed after the earth contained organic beings. Hence the name *transition* which he has imposed, as if they had been formed when the earth was passing from an uninhabited to an inhabited state. The date of their formation is conceived to be very remote, since the petrifactions which they contain are the remains of animal and vegetable species now extinct. It is in the transition rocks, too, that carbonaceous matter makes its first appearance in any assignable quantity.

---

* A mountain composed of the same layers of stone is said to be stratified; but it is composed of *beds*, when the layers are of different kinds of stone.

Class 3. *Floetz Formations.* The next grand class of formations has received the name of *floetz*, because they lie usually in beds much more nearly horizontal than the preceding. When not covered by a succeeding formation, they form hills which do not rise to the same height as the primitive or transition. They contain petrifactions more various in their nature than those which occur in the transition formations, and consist of shells, fish, plants, &c. indicating, that they were formed at a period when organized beings abounded.

The floetz formations lie immediately over the transition. They comprehend a great number of individual formations, each of which affects a particular situation. The following table exhibits a view of these different formations in the order of their position, as far as is known.

1. Old red sand-stone,
2. First floetz lime-stone,
3. First floetz gypsum with rock-salt,
4. Variegated sand-stone,
5. Second floetz gypsum,
6. Second floetz or shell lime-stone,
7. Third sand-stone or free-stone,
8. Chalk,
9. Independent coal,
10. Floetz trap.

The floetz trap formation lies over the rest, pretty much as the newer porphyry and sienite do over the older primitive formations.

Class 4. *Alluvial Formations.* The alluvial formations constitute the great mass of what is actually the earth's surface. They have been formed by the gradual action of rain and river water upon the other formations, and may be considered as very recent formations, or rather as deposites, the formation of which is still constantly going on. They may be divided into two kinds, those deposited in the valleys of mountainous districts, or upon the elevated plains which often occur in mountains; and those deposited upon flat land. The first kind consist of sand, gravel, &c. which constituted the more solid parts of the neighbouring mountains, and which remained when the less solid parts were washed away. They sometimes contain ores, (particularly gold and tin,) which existed in the neighbouring mountains. Sometimes the alluvial soil is washed, in order to separate these ores. On mountain-plains beds of loam are found. The second kind of alluvial deposite, or that which occupies the flat land, consists of loam, clay, sand, turf, and calctuff.* Here also occur earth and brown coal, (in this mineral amber is found,) wood coal, bituminous wood and bog iron-ore. The sand contains some metals, among others gold. The calctuff is a chemical deposite, and extends widely. It contains, plants, roots, moss, bones, &c. which it has encrusted. The clay and sand often contain petrified wood, and likewise skeletons of quadrupeds.

Class 5. *Volcanic Formations.* The volcanic formations are of two kinds; namely, *pseudo-volcanic* and the *true volcanic*. The pseudo-volcanic consists of minerals altered in consequence of the burning of beds of coal situated in their neighbourhood. Porcelain jasper, earth slag, burnt clay, columnar clay-iron-stone, and perhaps also polishing slate, are the minerals which have been thus altered. The real volcanic minerals are those which have been thrown out of the crater of a volcano. They are of three kinds. 1. Those substances which having been thrown out from time to time, have formed the crater of the mountain. 2. Those which have been thrown out of the crater in a stream, and rolled down the mountain; they constitute lavas. 3. The water which is occasionally thrown out of volcanoes, containing ashes and other light substances, gradually evaporating, leaves the earthy matter behind it: this substance constitutes volcanic tuff.

Until lately, the cause of volcanic fire was referred to sulphur, coal, and other inflammable matter, supposed to be burning in immense masses in the bowels of the earth; but the products of volcanic irruptions by no means agree with such an explanation. Earthy, alkaline, and metallic bodies, form the lava, and as the products of combustion always have a reference to the combustible, such matters were not likely to be produced from sulphur and coal.

We have only to suppose the access of water to large masses of different metals, and that it is decomposed by a galvanic action, as exemplified in experiments where copper and zinc are used in voltaic batteries. By these means, immense volumes of hydrogen gas are let free as the metals are oxidized. The violence of the action sets fire to the hydrogen, and the accumulated heat is so intense as to cause the fusion of every surrounding substance. By this theory, we are in possession of all the knowledge that is wanted to produce the tremendous effects of earthquakes and volcanoes:—for what power can resist the expansive force of steam? What power can resist the sudden evolution of gaseous fluid, accompanied by torrents of the earth in a state of fusion, which such a concurrence of circumstances must give rise to, and which are the actual concomitants of volcanic irruptions?

Of Veins.—Veins are mineral repositories which cut through the strata of which a mountain is composed, and which are filled with substances different from the rocks through which they pass. If we suppose, that the mountains in which veins occur were split by some means or other, and that the rifts thus formed were filled up by the matter which constitutes veins, we shall have a clear notion of these mineral repositories, and which are distinguished from beds by their direction, it being either perpendicular to the stratifications, or at least in an angle with it. Sometimes the strata through which veins pass are merely separated from each other; so that if we cut through the vein, we find the same strata of the rock on both sides of it; but sometimes also the corresponding strata on one side are lower than on the other, as if the portion of the rock on one side of the vein had sunk a little, while the portion on the other side kept its original position. In such cases the side of the rock against which the vein leans, or the floor of the vein, has always its strata highest up; whilst the strata of the portion of rock which leans over the veins, or the roof of the vein, are always lowest. So that this is the portion which appears to have sunk. Such a change of position in the strata is known in this country by the name of a *shift*.

In considering veins, there are two circumstances which claim our attention: namely, 1st. The shape of veins; and, 2dly. The substances with which they are filled.

1. All those mineralogists who have had the best opportunity of examining the shape of veins with correctness, represent them as widest above, and diminishing in size as they deepen, till at last they terminate in a point, as if they had been originally fissures. Sometimes, indeed, veins widen in different parts of their course, and afterwards contract again to their former size; but more commonly they continue diminishing to their extremity.

2. Sometimes these veins are either partially or entirely empty. In that case they are denominated *fissures*; but most commonly they are filled with a matter more or less different from the rock through which they pass. Sometimes the vein is filled up with one species of mineral. Thus we have veins of calcareous spar, of quartz, &c.; but when a vein is of any size, we usually meet with a variety of substances: these are disposed in regular layers always parallel to the sides of the vein, and they follow in their position a very regular order. One species of mineral constitutes the centre of the vein; on each side of this central bed the same layers occur in the same order from the centre to the side of the vein. To give an example; the vein Gregorius, at Freyberg, is composed of nine layers or beds. The middle of the vein consists of a layer of calcareous spar; on each side of this is a layer con-

---

* Stalactic or calcareous tufa.

sisting of various ores of silver mixed together; on each side of this a layer of brown spar; on each side of this a layer of galena; on each side of this again, and contiguous to the side of the vein, is a layer of quartz.

The following diagram will give the reader some notion of the relative position of these layers:—

Gneiss rock.	Quartz.	Galena.	Brown spar.	Silver ore.	Calcareous spar.	Silver ore.	Brown spar.	Galena.	Quartz.	Gneiss rock.

Sometimes the number of layers of which a vein is composed greatly exceeds this. Werner describes one in the district of Freyberg, in which the middle layer is calcareous spar, having on each side of it no less than thirteen layers arranged in the very same order.

Almost all the mineral substances which occur in the mass of rocks have been found in veins. We sometimes find them filled with different well-known stony bodies, as, granite, porphyry, limestone, basalt, wacke, green-stone, &c.; veins of quartz, clay, felspar, &c. are equally common.

Pit-coal and common salt, and almost all the metals, likewise occur in veins. Some veins are filled with water-worn pebbles, others with loam; sometimes with petrifactions.

Werner supposes that they were originally fissures formed in the rocks, and that they were all gradually filled by minerals deposited slowly from above, while the rocks in which they occur were covered by water, and that they were filled at the same time that the different formations were deposited.

This theory he has supported in his book on Veins, by a very complete enumeration of all the circumstances respecting their structure and appearances. He has shewn that they resemble fissures very exactly in their shape and direction; and that as they contain petrifactions and minerals altered by the action of water, they must of necessity have been filled from above.

Veins of course, according to this theory, are newer than the rocks in which they occur; and when two veins cross, that is obviously the newest which traverses the other without interruption, as the fissures constituting the second vein must have been formed after the first vein was filled up. When different veins contain the same minerals arranged in the same order, he conceives that they were filled at the same time, and says, that such veins belong to the same formation. When they differ in these respects, they belong to different formations. From the position of the respective veins with regard to each other, he deduces their relative age; and from this draws inferences respecting the relative age of the different mineral substances that occur in veins, similar to the inferences drawn respecting the age of the rocks which constitute the grand classes of formations.

GEOMETRY, denotes one of the most general and important of the mathematical sciences; and according to the present acceptation of the term, may be defined the science of extension, or of magnitudes, considered simply, generally, and abstractedly; or rather, it is that science which treats of the relative magnitudes of extended bodies. Geometry is distinguished into several denominations, as *analytical*, *elementary*, *practical*, &c.

Elementary GEOMETRY, is that which treats of the properties and proportions of right lines and right-lined figures, as also of the circle and its several parts, and is either theoretical or practical.

Theoretical GEOMETRY, has for its object the demonstration of certain geometrical propositions.

Practical GEOMETRY, relates to the performance of certain geometrical operations, such as the construction of figures, and the drawing of lines in certain positions, as parallel, perpendicular, &c. to other given lines.

GEOMETRY of the *Compass*, is a modern branch of practical geometry, in which all the problems are performed by means of the compasses only.

The most approved modern works on the elements of geometry are those of Euclid, as translated by Simson, Ingram, and Playfair; and the treatises of Professor Leisle, and M. Legendre. In practical geometry, we may recommend the works of Mallet, Clavins, Taequet, and Ozanam. In analytical geometry, those of Mongé and Garnier.

Prob. 1, fig. 1.—To bisect a given line A B.—1. From the points A, B, as centres, with any distance greater than half A B, describe arcs cutting each other in *c* and *d*. 1. Draw the line *c d* and the point E, where it cuts A B, will be the middle of the line required.

Prob. 2, fig. 2.—From a given point C, in a given right line A B, to erect a perpendicular. *When the point is near the middle of the line:* 1. On each side of the point C take any two equal distances C *d* and C *e*. 2. From *d* and *e*, with any radius greater than C *d*, or C *e*, describe two arcs cutting each other in *f*.

Fig. 1.

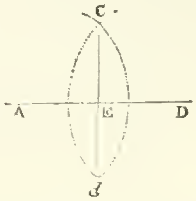
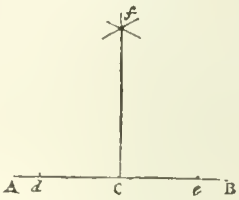


Fig. 2.



3. Through the points *f*, C, draw the line *f* C, which will be the perpendicular required.

Fig. 3 *When the point is at, or near, the end of the line.*—1. Take any point *d* above the line, and with the radius or distance *d* C, describe the arc *e* C *f*, cutting A B in *e* and C. 2. Through the centre *d* and the point *e*, draw the line *e d f*, cutting the arc *e* C *f*, in *f*. 3. Through the points *f* and C, draw the line *f* C, and it will be the perpendicular required.

Prob. 3, fig. 4.—From a given point C, without a given right line A B, to let fall a perpendicular.—1. From the point C, with any radius, describe the arc *d e*, cutting A B in *e* and *d*. 2. From the points *e*, *d* with the same, or any other radius, describe two arcs on the other side of the line, cutting each other in *f*. 3. Through the points C, *f*, draw the line C D *f*, and C D will be the perpendicular required.

Fig. 3.

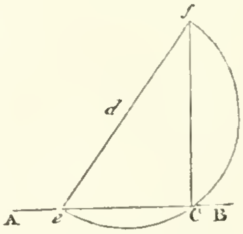
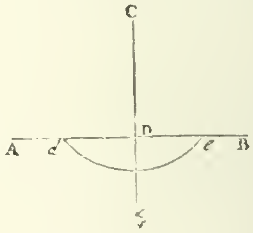


Fig. 4.



Prob. 4, fig. 5.—At a given point D, upon the right line D E, to make an angle equal to a given angle *a* B *b*.—1. From the point B, with any radius, describe the arc *a b*, cutting the legs B *a*, B *b*, in the points *a* and *b*. 2. Draw the line D E, and from the point D, with the same radius as before, describe the arc *e f*, cutting D E in *e*. 3. Take the distance *b a*, and apply it to the arc *e f*, from *e* to *f*. 4. Through the points D *f*, draw the line D *f*, and the angle *e* D *f* will be equal to the angle *b* B *a*, as was required.

Prob. 5, fig. 6.—To divide a given angle A B C into equal angles.—1. From the point B, with any radius, describe the arc A C. 2. From A and C, with the same, or any other radius, describe arcs cutting each other in *d*. 3. Draw the line B *d*, and it will bisect the angle A B C into three equal angles

Prob. 6, fig. 7.—To trisect, or divide, a right angle A B C into three equal angles.—1. From the point B, with any radius B A, describe the arc A C, cutting the legs B A. and B C, in A and C. 2. From the points A, and C, with the radius A B, or B C, cross the arc A C in *d*, and *e*. 3. Through the points *e*, *d*, draw the lines **B *c***, B *d*, and they will trisect the angles as was required.

Fig. 5.

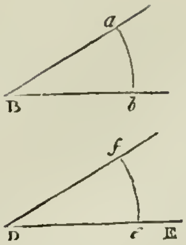


Fig. 6.

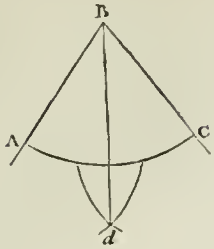


Fig. 7.

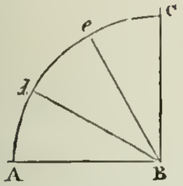
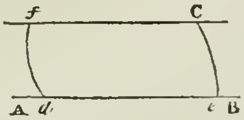


Fig. 8.



Prob. 7, fig. 8.—Through a given point C, to draw a line parallel to a given line A B.—1. Take any point *d*, in A B, upon *d* and C, with the distance C *d*, describe two arcs *e* C, and *d f*, cutting the line A B in *e* and *d*. 2. Make *d f* equal to *e* C; join C *f*, and it will be parallel to A B as required.

Fig. 9. *When the parallel is to be at a given distance* E F *from* A B.—1. From any two points *c* and *d*, in the line A B, with a radius equal to E F, describe the arcs *e* and *f*. 2. Draw the line C D to touch those arcs without cutting them, and it will be parallel to A B, as was required.

Prob. 8, fig. 10.—To draw a tangent to a given circle, that shall pass through a given point A.—1. From the centre O, draw the radius O A. 2. Through the point A, draw D E perpendicular to O A, and it will be the tangent required.

Fig. 9.

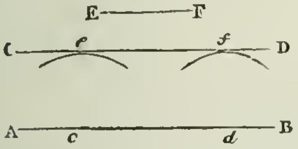
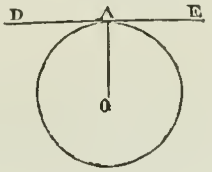


Fig. 10.



Prob. 9, fig. 11.—To draw a tangent to a circle, or any segment of a circle A B C, through a given point B, without making use of the centre of the circle.—1. Take any two equal arcs B *d*, *d e*, upon the circle, from the given point B, and draw the chord *e* B. 2. Upon B, as a centre, with the distance B *d*, describe the arc *f d g*, cutting the chord *e* B in *f*. 3. Make *d g* equal to *d f*, through *g* draw *g* B, and it will be the tangent required.

Prob. 10, fig. 12.—A circle A B C being given, and a tangent C H to that circle, to find the point of contact.—1. Take any point e, in tne tangent C H, and join *e* G. 2. Bisect *e* G in *f*, and with the radius *f e*, or *f* G, describe the semicircle *e* C G, cutting the tangent and the circle in C, it will be the point required.

Fig. 11.

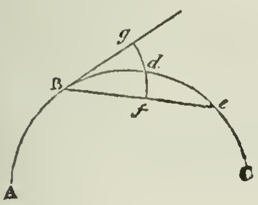
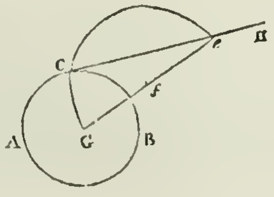


Fig. 12.



Prob. 11, fig. 13.—Given three points A, B, C, not in a straight line, to draw a circle through them.—1. Bisect the lines A B, and B C, by perpendiculars, meeting at *d*. 2. Upon *d*, with the distance *d* A, *d* B, or *d* C, describe A B C, it will be the circle required.

Fig. 13.

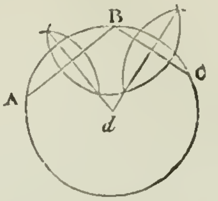
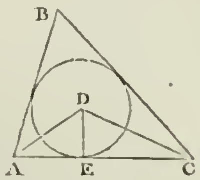


Fig. 14.



Prob. 12, fig. 14.—In a given triangle, A, B, C, to inscribe a circle.—1. Bisect any two angles A and C, with the lines A D, and C D. 2. From D, the point of intersection, let fall the perpendicular D E, it will be the radius of the circle required.

Prob. 13, fig. 15.—In a given square A B C D, to inscribe a regular octagon.—1. Draw the diagonals A C, and D B, intersecting at *e*. 2. Upon the points A, B, C, D, as centres, with a radius *e* C, describe arcs, *h e l*, *k e n*, *m e g*, *f e i*. 3. Join *f n*, *m h*, *k i*, *l g*, it will be the octagon required.

Prob. 14, fig. 16.—In a given circle, to inscribe an equilateral triangle, an hexagon, or a dodecagon. *For the equilateral triangle.*—1. Upon any point A, in the circumference with the radius A G, describe the arc B G F. 2. Draw B F, make B D equal to B F. 3. Join D F, and B D F will be the equilateral triangle required.—*For the hexagon.* Carry the radius A G six times round the circumference, the figure A B C D E F will be the hexagon.—*For the dodecagon.* Bisect the arc A B in *k*, and A *h* being carried twelve times round the circumference, will also form the dodecagon.

Fig. 15.

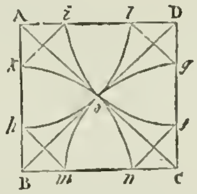
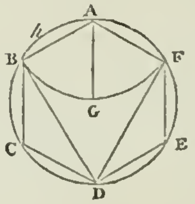


Fig. 16.



Prob. 15, fig. 17.—In a given circle to inscribe a square or an octagon.—1. Draw the diameters A C and B D, at right angles, 2. Join A B, B C, C D, D A, and A B C D will be the square,—*For the octagon.* Bisect the arc A B in E, and A E being carried eight times round, will also form the octagon.

Prob. 16, fig. 18.—In a given circle, to inscribe a pentagon, or a decagon. *For a pentagon.*—1. Draw the diameters A F and G H, at right angles, cutting each other in I. 2. Bisect G I in *f*, upon *f*, with the distance of *f* A, describe the arc A *g*; upon A, with the distance A *g*, describe the arc *g* E cutting the circle in E. 3. Join A E, and carry it round the circle five times, then will A B C D E be the pentagon required.—*For the decagon.* Bisect the arc A E in *i*, and D *i* being carried ten times round, will also form the decagon.

Fig. 17.

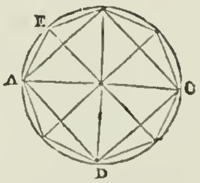


Fig. 18.

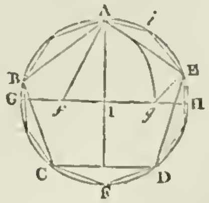


Fig. 19.

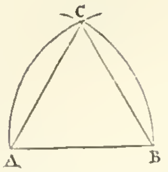
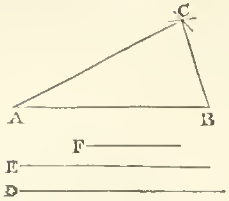


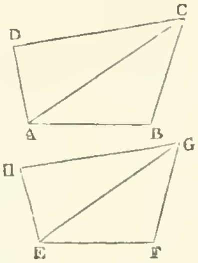
Fig. 20.



Prob. 17, fig. 19.—Upon a given line A B, to describe an equilateral triangle. 1. Upon the points A and B, with a radius equal to AB, describe arcs cutting each other at C. 2. Draw A C, and B C, it will be the triangle required.

Prob. 18, fig. 20.—To make a triangle, whose three sides shall be equal to three given lines D, E, F, any two of which are greater than the third.—1. Draw A B equal to the line D. 2. Upon A, with the distance E, describe an arc at C. 3. Upon B, with the distance F, describe another arc, intersecting the former at C. 4. Draw A C and C B, and A B C will be the triangle required.

Fig. 21.



Prob. 19, fig. 21.—To make a trapezium equal, and similar to a given trapezium A B C D.—1. Divide the given trapezium A B C D into two triangles, by a diagonal A C. 2. Make E F equal to A B, upon E F construct the triangle E F G, whose three sides will be respectively equal to the triangle A B C. 3. Upon E G, which is equal to A C, construct the triangle E G H, whose two sides E H, and G H, are respectively equal to A D and C D, then E F G H will be the trapezium required. In the same manner may any irregular polygon be made equal and similar to a given irregular polygon, by dividing the given polygon into triangles, and constructing the triangles in the same manner in the required polygon, as is shewn by figures.

Prob. 20, fig. 22.—To make a triangle equal to a given trapezium A B C D.—1. Draw the diagonal B D, make C E parallel to it, meeting the side A B, produced in E. 2. Join D E, and A D E will be the triangle.

Prob. 21, fig. 23.—To make a triangle equal to any given right-lined figure A B C D E.—1. Produce the side A B both ways at pleasure. 2. Draw the diagonals A D and B D, and make E F and C G parallel to them. 3. Join D F, D G, then D F G will be the triangle required. Much after the same manner may any other right-line figure be reduced to a triangle.

Fig. 22.

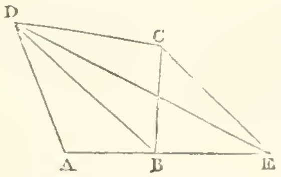
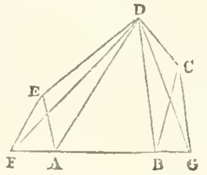


Fig. 23.



Prob. 22, fig. 24.—To reduce a triangle A B C to a rectangle.—1. Bisect the altitude A F in G, through G draw E D parallel to B C. 2. From C draw C D perpendicular to B C, and B E parallel to C D, then B C D E will be the rectangle required.

Fig. 21.

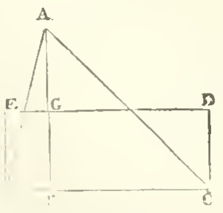
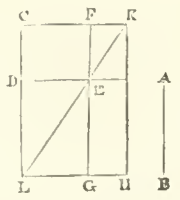


Fig. 25.



Prob. 23, fig. 25.—To make a rectangle, having a side equal to a given line A B, and equal to a given rectangle C D E F.—Produce the sides of the rectangle C F, D E, F E, and C D. 2. Make E G equal to A B, through G draw L H parallel to D E, cutting C D produced at L. 3. Draw the diagonal L E, and produce it till it cut C F at K. 4. Draw K H, parallel to E G, then will E G H be the rectangle required.

Prob. 24, fig. 26.—To make a square equal to a given rectangle A B C D.—1. Produce the side A B, make B E equal to B C. 2. Bisect A E in I, on I, as a centre with the radius I E or I A, describe the semicircle A H E. 3. Produce the side C B to cut the circle in H, on B H describe the square B H G F, and it will be the square required.

Prob. 25, fig. 27.—To make a square equal to two given squares A and B.—1. Make D E equal to the side of the square A, and D F perpendicular to D E, equal to the side of the square B. 2. Draw the hypothenuse F E; on it describe the square E F G H, it will be the square required.

Fig. 26.

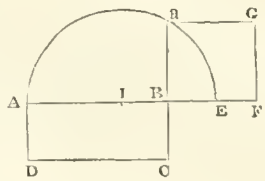
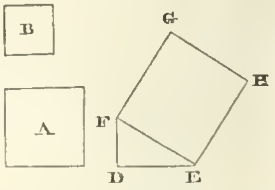


Fig. 27.



Prob. 26, fig. 28.—To make a square equal to three given squares A, B, C.—1. Make D E equal to the side of the square A, and D F perpendicular to D E, equal to the side of the square B. 2. Join F E, draw F G perpendicular to it. 3 Make F G equal to the side of the square C; join G E, then G E will be the side of the square required.

Prob. 27, fig. 29.—Two right lines A B, and C D, being given, to find a third proportional.—1. Make an angle H E I at pleasure, from E, make E F equal to C D, and E G equal to A B, join F G. 2. Make E H equal to E G, and draw H I parallel to F G, then E I will be the third proportional required, that is, E F : E G : : E H : E I, or C D : A B : : A B : E I.

Fig. 28.

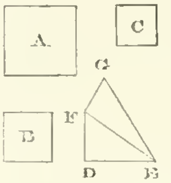
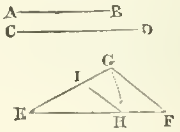


Fig. 29.



Prob. 28, fig. 30.—Three right lines A C, C D, E F, being given, to find a fourth proportional.—1. Make the angle H G I at pleasure: from G make G H equal to A B; G I equal to C D; and join H I. 2. Make G K equal to E F, draw K L through K parallel to H I, then G L will be the fourth proportional required; that is, G H : G I : : G K : G L, or A B : C D : : E F : G L.

Prob. 29, fig. 31.—To divide a given line A B, in the same proportion as another, C D is divided.—1. Make any angle K H I; and make H I equal to A B; then apply the several parts of C D from H to K, and join K I. 2. Draw the lines *o h*, *i f*, *k g*, parallel to I K, and the line H I will be divided in *h*, *i*, *k*, *l*, as was required.

Fig. 30

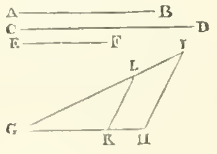
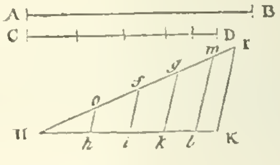


Fig. 31.



GERANIUM, in Botany, *Crane's Bill*, a genus of plants belonging to the monadelphia class, and in the natural order ranking the 14th order *Gruminales*.

GERARDIA, a genus belonging to the didynamia class, and in the natural method ranking under the 40th order.

GERMEN, the seed bud; defined by Linnæus to be the base of the pistillum, which contains the rudiments of the seed;

and, in progress of vegetation, swells, and becomes the seed itself. Hence,

GERMINATION, among Botanists, comprehends the precise time which seeds take to rise, after they have been committed to the soil, and AIR and WATER are the agents of germination. Millet, wheat, and several of the grasses, rise in a day; spinach, beans, turnips, &c. in three days; lettuce and dill in four; cucumber, gourd, melon, and cress, in five; radish and beet in six; cabbage in ten; parsley in fifty; peach, almond, and walnut in a year; and the sensitive plant retains its germinating virtue for thirty or forty years!

GILDING, the application of gold to the surfaces of bodies, is performed in two ways. Wood, leather, paper, and soft substances, are gilt by fastening on gold leaf by some kind of cement; but metals are gilded by a chemical process, called *water gilding*; while the former is called *oil gilding*, *burnished gilding*, and *japanner's gilding*. The instruments necessary for gilding are a cushion, knife, tip, and fitch, which are to be had in any colour shop. The gold leaf is either pure gold, *(yellow)*; pale gold, *(greenish;)* or Dutch gold, that is, copper coloured by the fumes of zinc. The cushion receives the gold, the knife parts it; the tip, a tool made by fastening the long hairs of a squirrel's tail between two cards, is used for taking up the gold leaf after it is cut, and laying it on the article to be gilded. A *fitch pencil* is used for the same purpose as the last, in taking up very small bits of gold leaf. A *ball of cotton* is used for pressing down the leaf, after it is laid on; a large *camel's hair brush* for dusting the work, and clearing away the superfluous gold.

Oil Gilding. Prime the work first with boiled linseed oil and white-lead; when dry, do it over with a thin coat of gold size, consisting of stone-ochre ground in fat-oil. When that is so dry as to feel clammy, it is fit for gilding. Spread the leaves of gold upon the cushion, cut them into slips of the proper width for covering the work, breathe upon the tip, as by moistening it thus, it will take up the leaves from the cushion. Apply them by the tip on the proper parts of the work, and press them down by the ball of cotton. Repair, by putting small pieces of gold on any parts which you have omitted to cover. When the work is covered, let it dry, and then clear it off with the brush. This sort of gilding, the easiest and least expensive, will stand the weather, and may at any time be cleaned with a little water.

Burnished Gilding is the sort of gilding generally used for picture-frames, looking-glasses, &c. The wood intended to be gilt in this manner, should first be sized, then done over with eight coats of size and whiting, to cover it with a body of considerable thickness. Having laid a sufficient quantity of whiting upon the work, it must be cleaned off, freeing all the cavities and hollows from the whiting that may have choked them up, and by proper moulds and tools, restoring the sharpness of the mouldings. It then receives a coat of size, made by boiling Armenian bole with parchment size. As this must not remain till it is quite dry, it is prudent not to lay on more at a time than can be gilt before it becomes too dry. The work being thus prepared, place it a little declining from you, and with clean water and a hair pencil moisten a part of it, apply the gold by the tip to the moistened part, it will immediately adhere to the work: proceed to wet the next part, and apply the gold as before, repeating this operation till the whole is completed; let not any drops of water come upon the gold already laid on, therefore no part should be missed in going over it at first, since it is not so easily mended as oil gilding. The work being thus gilt, remains twenty-four hours; when the parts designed to be burnished are polished with a dog's tooth, or an agate burnisher, but the gilding must not be quite dry when it is burnished.

Japanner's Gilding. To gild japanned work, we draw with a hair pencil, in gold size, the intended ornaments, and afterwards apply gold leaf or gold powder. The gold size is prepared thus: take of linseed-oil, and of gum-animi, four ounces. Boil the oil, add the gum-animi gradually in powder, stirring each quantity in the oil till it be dissolved, then put in another, till the whole be mixed. Let the mixture boil till it acquire a thicker consistence than tar; strain the whole through a coarse cloth, and keep it for use; when applied, it must be mixed with vermilion and oil of turpentine. Having laid on the gold size, and allowed it to dry, the gold leaf is applied in the usual way, or if it is not wanted to shine so much, gold powder is applied, which is made by grinding gold leaf upon a stone with honey, and afterwards washing the honey away with water. If the gilding is varnished, Dutch gold may be used, instead of real gold powder, or aurum musivum may be used.

To Write on Paper with Letters of Gold. Put gum-arabic into writing ink, and write in the usual way. When the writing is dry, breathe on it; the warmth and moisture will soften the gum, and cause it to fasten on the gold leaf, which may be laid on in the usual way, and the superfluous part burnished off. Or, instead of this use japanner's size.

To lay Gold upon White Earthenware, or Gloss. Draw the design upon the vessel to be gilt with japanner's gold size, moistening it if necessary with oil of turpentine. Set the work in a room free from dust, to dry, for an hour, then place it so near the fire that you could just bear the heat of it with your hand for a few seconds. Let it remain there till it feels clammy, then lay some gold leaf on it in the usual way. Then put the ware into an oven to be baked for about three hours. Glasses, &c. are gilt by drawing the figures with shell gold mixed with gum-arabic and borax. Then apply sufficient heat to it, and lastly burnish it.

To Gild on Glass or Porcelain, by Burning-in. Dissolve gold in aqua-regia, evaporate the acid by heat, and you will obtain a gold powder; or precipitate the gold from the solution by pieces of copper. Lay this gold on with a strong solution of borax and gum water, and it may be burned-in.

To Gild Metals. One method of applying gold upon metals is by first cleaning the metal to be gilt; gold leaf is then laid on it. This rubbed with a polished blood stone, and a certain degree of heat, adheres perfectly well. In this manner silver leaf is fixed and burnished upon brass, in the making of what is called *French Plate;* and sometimes gold leaf also is burnished upon copper and iron.

Gilding by Amalgamation is by previously forming the gold into a paste, or amalgam, with mercury. But to obtain an amalgam of gold and mercury, the gold is reduced into thin plates or grains, heated red-hot, and thrown into mercury previously heated, till it begins to smoke. Upon stirring the mercury with an iron rod, the gold totally disappears. The proportion of mercury to gold is generally as six or eight to one. The method of gilding by amalgamation, is chiefly used for gilding copper, or an alloy of copper, with a small portion of zinc, which receives the amalgam more readily, and is preferable on account of its colour, resembling that of gold more than the colour of copper. When the metal to be gilt is wrought or chased, it is previously covered with quicksilver before the amalgam is applied, that this may spread easier; but when the surface of the metal is plane, the amalgam may be applied to it directly. The metal to be gilt is first rubbed with aqua-fortis, which cleans the surface from any rust or tarnish that might prevent the union of the metals. The amalgam is then spread equally over the surface by a brush, and the mercury is evaporated by heat sufficient for that purpose; if the heat be too great, part of the gold also may be expelled, and part of it will run together, and leave some of the surface of the metal bare. While the mercury is evaporating, the work is from time to time taken from the fire, and examined, that the amalgam may be spread more equally by means of a brush; and any defective parts again covered, and that the heat may not be too suddenly applied. When the mercury has evaporated, which is known by the surface becoming entirely of a dull colour, the metal then undergoes other operations, by which it receives the fine gold colour. First, the gilded piece of metal is rubbed with a *scratch-brush* (a brush made of brass wire,) till its surface is quite smooth; it is then covered with *gilding wax*, and again exposed to the fire till the wax be burnt off. This wax is composed of bees-wax, mixed with either red ochre, verdigris, copper scales, alum, vitriol, or borax; but the saline substances are sufficient without any wax. The colour of the gilding is heightened by this operation. The gilt surface is then covered with a saline composition of nitre, alum, or other vitriolic salt, ground together, and mixed into a paste with water and urine. The metal thus covered is exposed to a certain degree of heat, and then quenched in water. By this method its colour is further improved, and brought nearer to that of gold. This effect seems to be produced by the acid of nitre (which is disengaged by the sulphuric acid of the alum, during the exposure to heat) acting upon any particles of copper which may happen to lie upon the gilded surface. Lastly, some artists think that they give an additional lustre to their gilt work, by dipping it in a liquor prepared by boiling some yellow materials, as sulphur, orpiment, or turmeric. The only advantage of this operation is, that part of the yellow matter remains in some of the hollows of the carved work, in which the gilding is apt to be more imperfect, and to which it gives a rich and solid appearance.

Gilding Iron or Steel. In gilding iron or steel by means of an amalgam, as the metal has no affinity for the mercury, an agent is employed to dispose the surface to receive the gilding. This agent is, a solution of mercury in nitrous acid (aqua fortis,) or what workmen call quicksilver water, applied to the parts to be gilded; the acid, by a stronger affinity, seizes on a portion of the iron, and deposits in its place a thin coating of mercury, which will not refuse a union afterwards with the gold amalgam that may be applied; by this process, the nitrous acid injures the surface of the metal, and the union of the mercury being very slight, a bright and durable gilding cannot be obtained.

Another Method. Apply a solution of *blue vitriol* with a camel's-hair pencil, to the parts of the steel to be gilt, and by a chemical action, similar to that we described as taking place when a solution of nitrate of mercury is employed, a thin coating of copper is precipitated on the metal. The copper has an affinity for mercury, and a union is thus effected between the amalgam and the iron or steel. But the surface is injured by the action of the acid employed, and still a heat sufficient to volatilize the mercury must be afterwards used.

Gilding of Iron by Heat. When the surface has been polished bright, it is heated till it becomes blue. Gold leaf is then applied, and burnished down. It is then heated again, another layer of gold burnished on it, and in this manner three or four coats are given, according to the intended strength of the gilding. This, though a more laborious process than the two last, is not attended with so much risk.

An Improved Process for Gilding Iron or Steel. This process, less known among artists than it deserves to be, cannot fail to be useful to those who gild iron or steel. The first part of the process consists in pouring over a solution of gold in nitro-muriatic acid (aqua regia) about twice as much ether. This must be done with caution, and in a large vessel. These liquids are then shaken together, and as soon as the mixture is at rest, the ether will be seen separating itself from the nitro-muriatic acid, and floating on the surface. The nitro-muriatic acid becomes more transparent, and the ether darker, than they were before; because the ether has taken the gold from the acid. The whole mixture is then poured into a glass funnel with a small aperture, which must not be opened till the fluids have separated themselves from each other. It is then opened, and the nitro-muriatic acid will run off, it having taken off the lowest place by its greater gravity; the aperture is then shut, and the funnel will be found to contain nothing but ether mixed with gold. This is preserved for use in bottles well closed. In order to gild iron or steel, the metal is first well polished with emery, or the finest crocus martis, or colcothar of vitriol, and common brandy. The auriferous ether is then applied with a small brush; the ether soon evaporates, and the gold remains on the surface of the metal. The metal may then be put into the fire, and afterwards polished. By means of this auriferous ether, figures of all kinds may be delineated on iron, by a pen or fine brush. Instead of ether, the essential oils of turpentine or lavender may be used which will also take gold from its solution.

Cold Gilding of Silver. Dissolve gold in nitro-muriatic acid, dip some linen rags in the solution, then burn them, and preserve the ashes. Whatever is to be gilded must be previously well burnished: a piece of cork is then dipped, first into a solution of salt and water, and afterwards into the black powder, and the piece being rubbed with it must be burnished.

Gilding Copper or Brass is thus done: evaporate a saturated solution of gold to the consistence of oil, let it shoot into crystals, which dissolve in pure water, immerse in this the articles to be gilded, wash them afterwards in pure water, and burnish them.

Grecian Gilding. Dissolve mercury in muriatic acid, (spirits of salt,) which will give a muriate of mercury. Equal parts of this and sal ammoniac are then mixed, and dissolved in aquafortis. Put some gold into this, and it will dissolve. This applied to silver, becomes black; but by heating, it assumes the appearance of gilding.

To make Shell Gold. Grind, in a mortar, gold leaf and honey, then wash away the honey with water, and mix the gold powder with gum water. This may be applied to any article with a camel's-hair pencil, in the same way as any other colour.

GIMBALS, the brass rings by which a sea-compass is suspended in its box, so as to counteract the effect of the ship's motion, and keep the card horizontal.

GIMBLETING, a term applied to the anchor, to denote the action of turning it round by the stock, so that the motion of the stock appears similar to that of the handle of a gimblet when it is employed to turn the wire.

GIN, in Mechanics, a machine for driving piles, fitted with a windlass and winch at each end, where eight or nine men heave, and round which a rope is reeved that goes over the wheel at the top; one end of this rope is seized to an iron monkey that hooks to a beetle, of different weights, according to the piles that are to be driven, being from 8 to 13 hundred weight; and when hove up to a cross piece, near the wheel, it unhooks the monkey, and lets the beetle fall on the upper end of the pile, and thereby forces the same into the ground; then the monkey's own weight overhauls the windlass, in order for its being hooked again to the beetle. *See* PILE *Engine.*

GIRT, the situation of a ship which is moored so tight by her cables, extending from the hawse to two distant anchors, as to be prevented from swinging or turning about according to any change of the wind or tide, to the current of which her head would otherwise be directed. The cables are extended in this manner by a strong application of mechanical powers within the ship; so that, as she veers or endeavours to swing about, her side bears upon one of the cables, which catches on her heel, and interrupts her in the act of traversing. In this position she must ride, with her broadside or stern to the wind or current, till one or both of the cables are slackened so as to sink under the keel; after which, the ship will readily yield to the effort of the wind or current, and turn her head thither.

GIRT *Line*, a rope passing through a single block on the head of the lower masts, to hoist up the rigging thereof, and the persons employed to place the rigging and cross-trees on the mast-heads; the girt-line is, therefore, the first rope employed to rig a ship, after which it is removed till the ship is to be unrigged.

GIVEN, is a term frequently used by mathematicians, to denote something supposed to be known. Thus, if a magnitude be known, it is said to be a *given* magnitude. If the position of a thing be known, it is *given* in position; thus, if a circle be described with a known radius, its centre is *given* in position, and its circumference *given* in magnitude, and the circle itself is said to be *given* both in magnitude and position. If the kind or species of a figure be known, it is said to be *given* in species; if the ratio between two quantities be known, these quantities are said to have a *given* ratio, &c. &c.

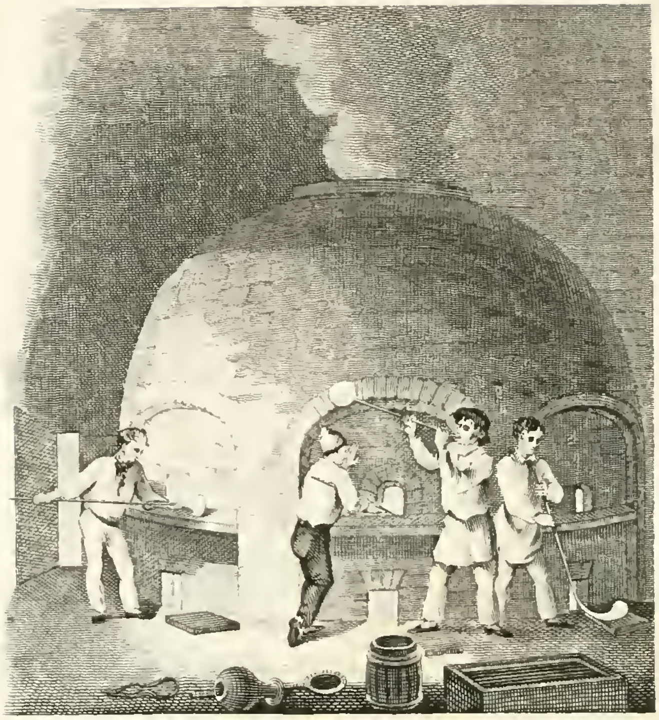
GIVE WAY, is the order to a boat's crew to row after having ceased for a short time, or to increase their exertions if they were before rowing. *Give way together*, implies that men should keep time together in rowing, so as that the oars should all dip and rise together, whereby their several forces are exerted as one.

GLACIS, in Fortification, the mass of earth which serves as a parapet to the covered way, sloping easily towards the champaign field. In Building, *glacis* expresses any declivity, which is less steep than the slope called Talus In Gardening, a descent sometimes begins in a Talus, and ends in a glacis.

GLAIR EGGS, is the same as the white of eggs, used as a varnish for preserving paintings. For this purpose, it is beat

GLASS MANUFACTURE

Fig 1 Blowing



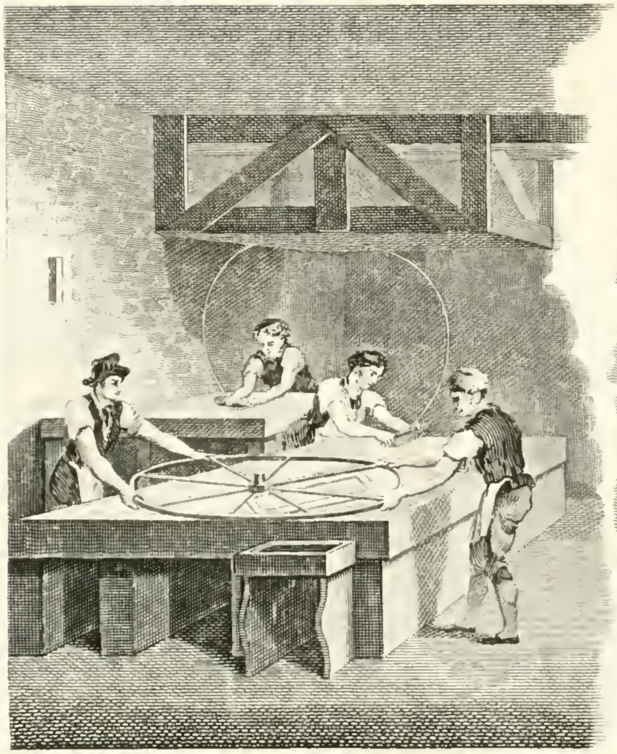


Fig 3 Polishing

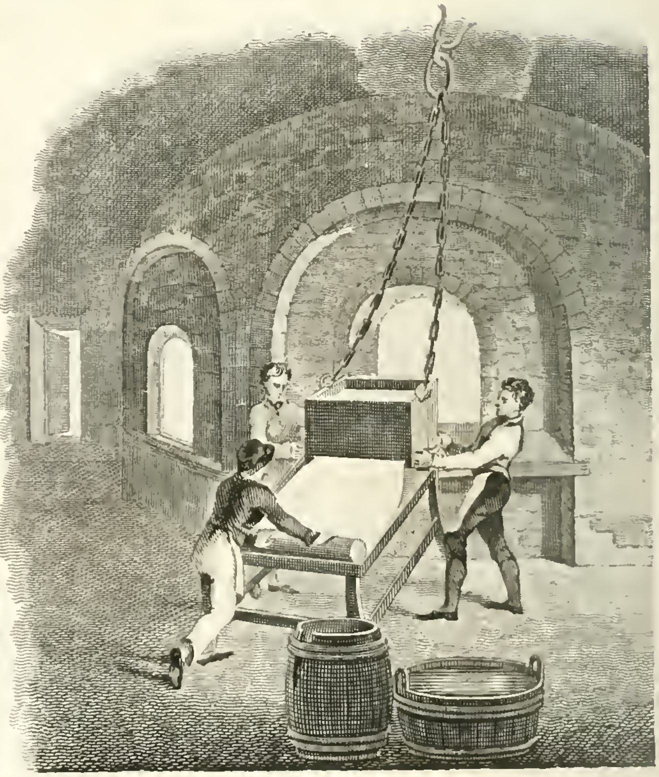


Fig 2 Casting

to an unctuous consistence, and commonly mixed with a little brandy or spirits of wine, to make it work more freely, and with a little lump-sugar to give it body and prevent it cracking, and then spread over the picture with a fine elastic brush.

GLASS, a transparent, brittle metal, made of sand melted in a strong fire with fixed alkaline salts, lead, slags, &c. till the whole becomes perfectly clear and fine. And the manufactured glass may be divided into three kinds—white transparent glass, coloured glass, and common green or bottle glass. Of the first of these, there are many different kinds, as flint glass, crystal, mirror plate, window glass, &c. Of the coloured glass, there is also a great variety, resulting from accidental combinations or preparations.

Accident is said to have discovered the constituent parts of glass. Some merchants, with a freight of soda, cast anchor at the mouth of the river Belus, in Phenicia, and were dressing their dinner on the sand, using large lumps of the soda as supports for their kettles. The fire melting the soda, and the siliceous earth together, exhibited *glass*. A manufacture was instantly established, and to this place it was for a long time confined. What was the soda previously used for?

Glass was made in great perfection among the ancients; as drinking glasses, prisms, and coloured glasses of various kinds. It was known to the Romans, but was by no means common among them, for Nero paid £50,000 for two glass cups. Glass was first used for windows in the third century.

Glass, as we have remarked, is a solid, transparent, brittle, substance, produced by melting together sand, flint, and alkaline salts. There are other saline matters employed in the manufacture of glass, as *poeverine*, or *rochetta*, which is prepared from glass wort or *salsola kali*, an indigenous plant, but which is chefly imported from Spain, where it is cut down in the summer, dried in the sun, and burned in heaps, when the ashes fall into a pit, where they concrete into a hard mass. A similar salt is obtained from the ashes (*kelp*) of the common sea-wrack. The sand used in the manufacture of glass is found at Lynn in Norfolk, Maidstone in Kent, &c. &c.

The following are the processes employed in making glass:

Fritting. The various materials are carefully washed, and after extracting all the impurities, are conveyed to the furnace in pots made of tobacco-pipe clay. The produce of this process is called the *frit*, which is again melted in large pots or crucibles, till the whole mass becomes beautifully clear, and the dross rises to the top.

Blowing, (see Plate, fig. 1,) is the next process, which in round glass, as phials, drinking glasses, &c. is thus performed. The workmen dip the end of long iron pipes, red-hot, into the liquid glass, then roll it on a polished iron plate to give it an external even surface; they next blow down the iron pipe till it enlarges the metal like a bladder, and, if necessary, roll it again on the iron plate, and proceed to form it into a globular, or any other required. The glass is then transferred from the blowing pipe, by dipping the end of another iron rod into the liquid glass, which adheres to the heated rod, and with which the workman sticks it to the bottom of the vessel; then with a pair of pincers, wetted with water, he touches the neck, which immediately cracks, and on being slightly struck, separates at the end of the blowing pipe, and becomes attached to the iron rod. The vessel is next carried up to the mouth of the furnace to be heated and softened, that the operator may finish it. If the vessel require a handle, the operator forms it separately, and unites it while melting-hot, forming it with pincers to the requisite shape and pattern.

Annealing is the removing of the glass after it has been blown, or cast, into a furnace, whose heat is not sufficiently intense to melt it; and gradually withdrawing the article from the hottest to a cooler part of the annealing chamber, till it is cold enough to be taken out for use.

Colouring. The different coloured glasses owe their tints to the different metallic oxydes mixed with the materials while in a state of fusion.

Blue, glass is formed by the oxyde of cobalt;
Green, by the oxyde of iron or copper;
Violet, by the oxyde of manganese;
Red, by a mixture of the oxydes of copper and iron;
Purple, by the sxyde of gold;
White, by the oxyde of arsenic and zinc;
Yellow, by the oxyde of silver, and by combustible bodies;
And *Black*, from a mixture of oxyde of manganese, cobalt, and iron.

In this manner is made those elegant *pastes*, which so faithfully imitate, and not unfrequently excel, in brilliance, their originals, the gems of antiquity. The glass, however, for this purpose, is prepared in a peculiar manner, and requires great nicety. It combines purity and durability. *Opaque* glass is made by the addition of the oxyde of tin, and produces that beautiful imitation of enamel which is so much admired. Dials for watches and clocks are made in this manner, and are manufactured exclusively at the Falcon Glass-house, Surrey side of Blackfriars' Bridge.

Cutting or *Ornamenting*, is effected by a machine, in which there is a large wheel turned by a winch. The band of this wheel passes round a pulley on the axle of a wheel or cutter, which it turns with great velocity. Beneath the cutter a cistern is placed, and above it a small cask containing water, the cock of which is so placed as to drop very slowly on the circumference of the cutter. The operator, after dressing the edge of the cutter with emery paste, applies successively the parts of the glass which are to be cut, and dexterously moves it as the parts are sufficiently ground away.

The principal sorts of glass are, *crown glass*. The best window glass is made of white sand, purified barilla, saltpetre, borax, and arsenic, melted together; and if the glass assume a yellowish hue, the defect is removed by adding a sufficient quantity of manganese.

Newcastle glass, generally used in England, is of an ash colour, frequently speckled, streaked, and blemished. It is made from white sand, unpurified barilla, common salt, arsenic, and manganese.

The *bottle* or *green* glass, usually made of common sand, lime, and some clay fused with an impure alkali, is very hard, and resists the corrosive action of all liquids much better than flint glass; the green colour is owing to the iron: it is well adapted for chemical vessels.

Flint glass, the most fusible of any, is used for bottles, utensils intended to be cut and polished, and for various ornamental purposes. The best kind is composed of white siliceous sand, pearl ash, red oxyde of lead, nitrate of potash, and the black oxyde of manganese.

Plate glass, so called from its being cast in plates or large sheets, is the most valuable, and is employed for mirrors and the windows of carriages. It is composed of white sand cleansed with purified pearl ashes and borax. But should the metal appear yellow, it is restored to its pellucid transparency by the addition (in equal proportions) of a small quantity of manganese and arsenic. It is cast on a large horizontal table, and all excrescences pressed out by passing a large roller over the metal. To polish the glass, it is laid on a large horizontal table of freestone perfectly smooth; and then a smaller piece of glass, fastened to a plank of wood, is passed over the other till it has received its due degree of polish. But to facilitate this process, water and sand are used as in the polishing of marble; and, lastly, Tripoli stone, smalt, and emery, to give it lustre.

We must go a little more into the detail of this art. Fig. 2 represents the casting furnace with its melting pot, &c. A is is the bocca, or mouth of the furnace; B the cistern that conveys the liquid glass out of the melting pots in the furnace to the casting table D. This cistern is brought out of the furnace by means of the iron chain suspended on the hook over the bocca. The cistern thus placed on its carriage, and moved over the table, the bottom, which is moveable, is slipped off the torrent of liquid flaming matter, and flows over the surface of the table, where it is ruled to its proper thickness and dimension by the rulers EE, and the roller F in the workman's hands. The cisterns remain six hours in the furnace; the metal is melted in about 24 hours. The glass is now to be ground, polished, and foliated.

Grinding and *Polishing*, fig. 3, gives plate glass a fine lustre. The grinder takes it rough out of the hands of the caster, and laying it upon a stone table, to which it is fixed with stucco, he lays another rough glass, half the size of the former, upon it.

To the smaller glass a plank is fastened by means of stucco, and to the whole a wheel B, made of hard light wood, about six inches in diameter, by pulling of which from side to side, and from end to end of the glass, a constant attrition is kept up; and by allowing water and fine sand to pass between the plates, the whole is very finely polished; but to give the finishing polish, powder of smalt is used. As the upper glass grows smoother it is taken away and a rougher one substituted in its stead, and so on till the work is done. Except in the very largest plates, the workmen polish their glass by means of a plank having four wooden handles to move it; and to this plank a plate of glass is cemented, as above.

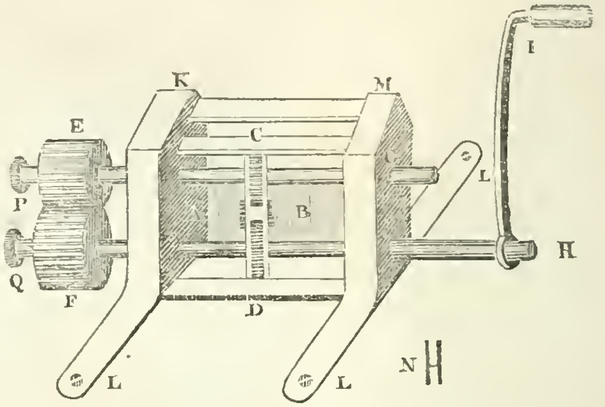
Achromatic Flint Glass. The important discovery of M. Guinaud in the manufacture of flint glass for large telescopes, shall close our article upon Glass. The excise laws of England have prevented our artists from attempting to melt glass on a proper scale for making lenses for achromatic telescopes; but in France, where no such restrictions exist, numerous attempts have been made to perfect the manufacture of flint glass for optical purposes; and M. Guinaud's labours have been finally crowned with complete success. The almost total impossibility of procuring flint glass exempt from striæ, suggested to this artist the construction of a furnace capable of melting two hundred weight of glass in one mass, which he sawed vertically, and polished one of the sections, in order to observe what had taken place during fusion. He discovered his metal to be vitiated by striæ, specks or grains with cometic tails, and from time to time as he obtained blocks including portions of good glass, his practice was to separate them by sawing the blocks into horizontal sections, or perpendicular to their axis. A fortunate accident conducted him to a better process. While his men were one day carrying a block of this glass on a hand-barrow to a saw-mill which he had erected at the fall of the Doubs, the mass slipped from its bearers, and rolling to the bottom of a steep and rocky declivity, was broken to pieces. M. Guinaud was at first grieved at this misfortune, but having selected those fragments which appeared perfectly homogeneous, he softened them in circular moulds, in such a manner, that on cooling he obtained disks that were afterwards fit for working. To this method he adhered, and contrived a way of clearing his glass while cooling, so that the fractures should follow the most faulty parts. When flaws occur in the large masses, he removes them by cleaving the pieces with wedges; he then melts them again in moulds, which give them the form of disks, taking care to allow a little of the glass to project beyond one of the points of the edge, so that the optician may be enabled to use that portion of glass in making a prism, which shall give the measure of the index of refraction, and thus obviate the necessity of cutting the lens. The Astronomical Society of London have tried disks of M. Guinaud's flint achromatic glass, which seems entirely homogeneous, and exempt from fault. This material, Mr. Tully, a very able optician in London, considers different from our English flint glass, as it grinds and polishes much easier.

Glass, the usual appellation for a telescope. *Night-Glass*, a telescope made for viewing objects at night.

Half-hour-Glass, frequently called the *Watch-Glass*, is used to measure the time which each watch has to stay upon deck. *Half-minute and Quarter-minute-Glasses*, are used to ascertain the rate of a ship's velocity, measured by the log; these glasses should be frequently compared with a good stop watch, to determine exactly how many seconds they run. *To Flog or Sweat the Glass*, is to turn it before the sand has quite run out, and thereby gaining a few minutes in each half hour, make the watch too short. *Glass* is used in the plural, to denote the duration of any action; as, they fought yard-arm and yard-arm three glasses, *i. e.* three half-hours, or an hour and a half.

GLAUCOMA, in Surgery, a disease in the eye, by which the crystalline humour turns bluish, and its transparency diminishes, so that all objects appear to the patient as through a cloud or mist; but when the disorder has reached its height, the visual rays are all intercepted, and blindness follows, especially in aged persons. The applications are those used internally in the *gutta serena*.

GLAZIER'S Vice, a machine for drawing window lead, and may be thus described. P G, Q H, are two axles, running in the frame K L, M L. C D, are two wheels of iron, case-hardened, 1½ inch broad, and of the thickness of a pane of glass; these wheels are fixed to the axles, and run very near one another, their distance not exceeding $\frac{1}{10}$ of an inch: across their edges several nicks are cut, the better to draw the lead through. E, F, are two pinions, each of twelve leaves, turning one another, and going upon the ends of the axles, which are square, being kept fast there by the nuts P Q, which are screwed fast with a key. A B, are two cheeks of iron, case-hardened, and fixed on each side to the case with screws; these are cut with an opening where the two wheels meet, and set so near to the wheels as to leave a space equal to the thickness of the lead; so that between the wheels and the cheeks there is left a hole of the form represented at N, which is the shape of the lead when cut through. The frame K L M L is held together by cross bars passing through the sides, and screwed on; and a cover is put over the machine to exclude the dust. The whole is screwed down fast to a bench by screw nails L L. When the vice is used, the lead to be drawn is first cast in moulds, into pieces a foot long, with a gutter on each side. One of these pieces is taken, and an end of it sharpened a little with a knife; then, being put into the hole between the wheels, by turning the handle I the lead is drawn through the vice, and receives the form designed.



GLOBE, in Geometry, a round solid body, which may be conceived to be generated by the revolution of a semicircle about its diameter. *See* Sphere.

Globe, or *Artificial Globe*, in Geography and Astronomy, is more particularly used to denote a globe of metal, plaster, paper, pasteboard, &c.; on the surface of which is drawn a map, or representation of either the heavens or the earth, with the several circles which are conceived upon them: the former being called the *Terrestrial Globe*, and the latter the *Celestial Globe*.

The Terrestrial Globe. (*See Plate.*)—The terrestrial globe is an artificial representation of the earth, which we have already described. The diurnal motion of this globe is from west to east.

The Celestial Globe is an *inverted* representation of the heavens, on which the stars are marked according to their several situations. The diurnal motion of this globe is from east to west, to represent the apparent diurnal motion of the sun and stars. The eye is supposed to be placed in the centre of this globe, but in fact it is beyond the stars.

The Axis of the earth, fig. 2, is an imaginary line A B passing through its centre; and the wire on which the artificial globe turns represents this line.

The Poles of the earth are the extremities of this axis; that on the north is called the Arctic, that on the south the Antarctic pole. The celestial poles are imaginary points in the heavens, exactly above the terrestrial poles.

The brazen Meridian, A E, fig. 6, the circle in which the artificial globe turns, divided into 360 degrees. Every circle is supposed to be divided into 360 equal parts, called degrees, each degree into sixty equal parts called minutes, each minute into sixty equal parts called seconds, &c.; a degree is therefore only a relative idea, and not an absolute quantity, except when

ARTIFICIAL GLOBES, CELESTIAL AND TERRESTRIAL.

Armillary Sphere.

Fig 1

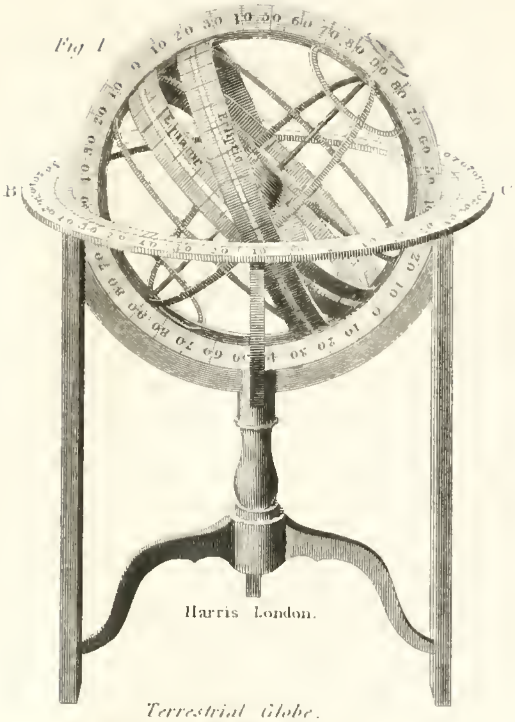
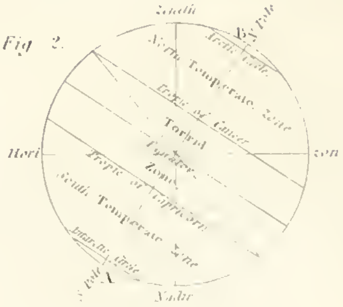
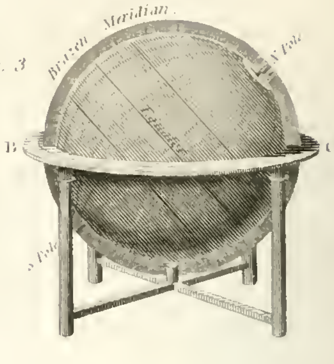


Fig 2.



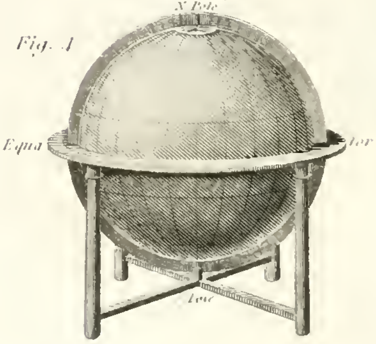
An Oblique Sphere.

Fig. 3



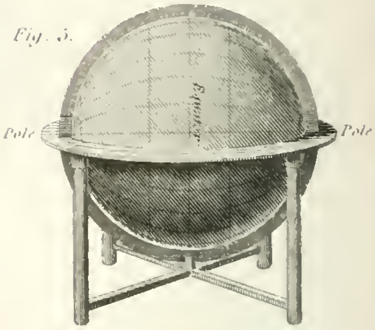
A Parallel Sphere.

Fig. 4



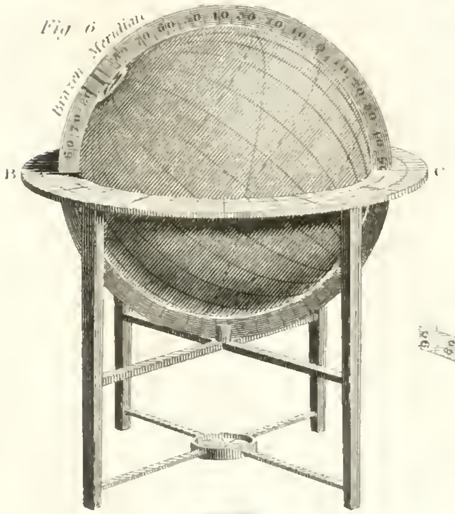
A Direct Sphere.

Fig. 5.

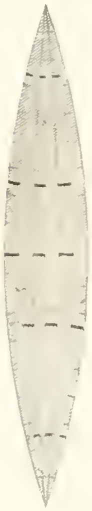


Terrestrial Globe.

Fig 6



Projection of a Gore for covering a Globe



Terrestrial Globe illuminated to illustrate the Seasons &c.

Fig 8.

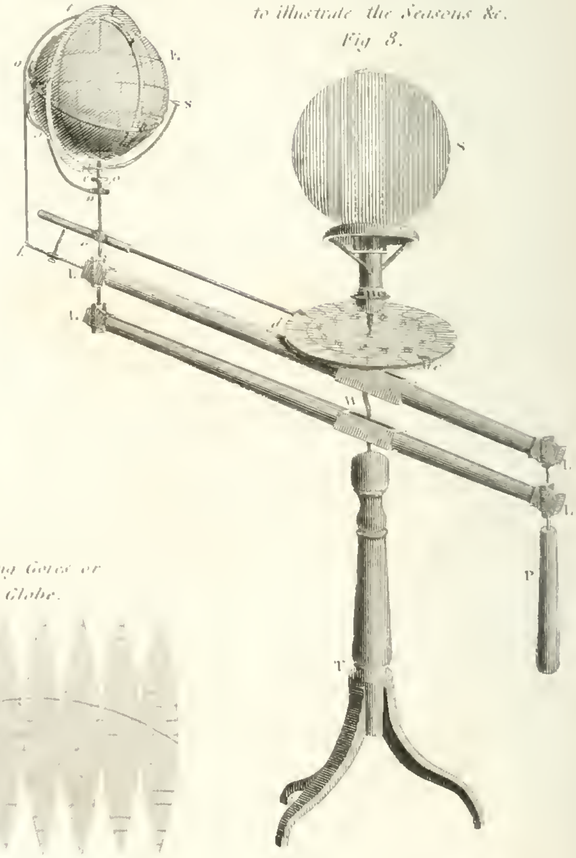


Fig E.

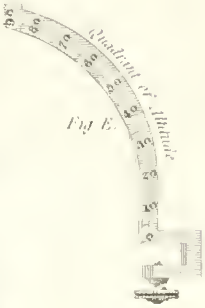
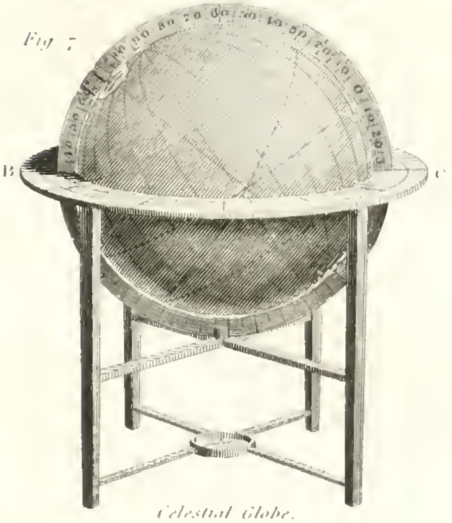
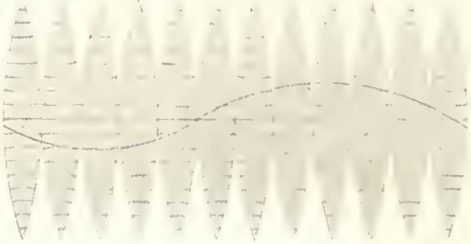


Fig 7



Celestial Globe.

The method of drawing Gores or Covering for a Globe.



applied to a great circle of the earth, as to the equator or to a meridian, in which cases it is sixty geographical miles, or 69½ English miles. A degree of a great circle in the heavens is a space nearly equal to twice the apparent diameter of the sun; or to twice that of the moon when considerably elevated above the horizon. Degrees are marked with a small cipher, minutes with *one* dash, seconds with *two*, thirds with *three*, &c. Thus, $25^\circ\ 14'\ 22''\ 35'''$, are read 25 degrees, 14 minutes, 22 seconds, 35 thirds.

In the upper semicircle of the brass meridian, fig. 6, these degrees are numbered 10, 20, &c. to 90, from the equator towards the poles, and are used for finding the latitudes of places. On the lower semicircle of the brass meridian they are numbered 10, 20. &c. to 90 from the poles towards the equator, and are used in the elevation of the poles.

Great Circles, as the equator, ecliptic, and the colures, divide the globe into two equal parts. See fig. 2.

Small Circles, as the tropics, polar circles, parallels of latitude, &c. divide the globe into two unequal parts. Fig. 2.

Meridians, or lines of longitude, are *semicircles*, extending from the north to the south pole, and cutting the equator at right angles. Every place upon the globe is supposed to have a meridian passing through it, though there be only twenty-four drawn upon the terrestrial globe; the deficiency is supplied by the brass meridian. When the sun comes to the meridian of any place (not within the polar circles) it is noon or mid-day at that place. Figs. 3, 4, and 5.

The First Meridian is that from which geographers begin to reckon the longitudes of places. In English maps and globes the first meridian is a semicircle supposed to pass through London, or the royal observatory at Greenwich.

The Equator, a great circle of the earth, equidistant from the poles, divides the globe into two hemispheres, northern and southern. The latitudes of places are reckoned from the equator, northward and southward, and the longitudes are reckoned upon it eastward and westward. The equator, when referred to the heavens, is called the *equinoctial*, because when the sun appears in it, the days and nights are equal all over the world, *viz.* twelve hours each. The declination of the sun, stars, and planets, are counted from the equinoctial northward and southward; and their right ascensions are reckoned upon it eastward round the celestial globe from 0 to 360 degrees. Fig. 5.

The Ecliptic is a great circle in which the sun makes his apparent annual progress among the fixed stars. It is the real path of the earth round the sun. The intersection at 23° 28′ is called the equinoctial points; the ecliptic is situated in the middle of the zodiac. The apparent path of the sun is either in the equinoctial or in lines nearly parallel to it, and his apparent annual path may be traced in the heavens, by observing what particular constellation in the zodiac is on the meridian at midnight; the opposite constellation will shew, very nearly, the sun's place at noon on the same day. Figs. 1 and 2.

The Zodiac on the celestial globe is a space which extends about 8° on either side of the ecliptic. Within this belt the motions of the planets are performed. Fig. 1.

Signs of the Zodiac. The ecliptic and zodiac are divided into twelve equal parts, called signs, each containing 30°; and the sun makes his apparent annual progress through the ecliptic at the rate of nearly a degree in a day. The names of the signs, and the days on which the sun enters them, are as follow:

SPRING SIGNS.

♈ *Aries*, the Ram, 21st of March.
♉ *Taurus*, the Bull, 19th of April.
♊ *Gemini*, the Twins, 20th of May.

SUMMER SIGNS.

♋ *Cancer*, the Crab, 21st of June.
♌ *Leo*, the Lion, 22d of July.
♍ *Virgo*, the Virgin, 22d of August.

All northward of the equator.

AUTUMNAL SIGNS.

♎ *Libra*, the Balance, 23d of September.
♏ *Scorpio*, the Scorpion, 23d of October.
♐ *Sagittarius*, the Archer, 22d of November.

WINTER SIGNS.

♑ *Capricornus*, the Goat, 21st of December.
♒ *Aquarius*, the Waterbearer, 20th of January.
♓ *Pisces*, the Fishes, 19th of February.

These are called southern signs, being all south of the equator.

The Colures, two great circles passing through the points Aries and Libra, and the poles of the world; Cancer and Capricorn, and the poles of the world, have their uses in mechanical geography. That passing through Aries and Libra, is called the equinoctial colure; that passing through Cancer and Capricorn, the solstitial colure. Fig. 1.

The Tropics are two smaller circles, each 23° 28′ from the equator, with which they are parallel; the northern is called the Tropic of Cancer, the southern the Tropic of Capricorn. The tropics are the limits of the torrid zone, northward and southward; and within these boundaries alone is the sun ever seen vertical. Figs. 1 and 2.

The Polar Circles are two small circles, parallel to the equator (or equinoctial), at the distance of 66° 32′ from it, and 23° 28′ from the poles. The northern is called the Arctic, the southern the Antarctic circle. Figs. 1 and 2.

Parallels of Latitude are small circles drawn through every ten degrees of latitude, on the terrestrial globe, parallel to the equator. Every place on the globe is supposed to have a parallel of latitude drawn through it, though there are generally only 16 parallels of latitude drawn on the terrestrial globe.

The Hour Circle on the artificial globes is a small circle of brass, with an index or pointer fixed to the north pole. The hour circle is divided into twenty-four equal parts, corresponding to the hours of the day; and these are again subdivided into halves and quarters. Figs. 6 and 7.

The Horizon is a great circle which separates the visible half of the heavens from the invisible; the earth being considered as a point in the centre of the sphere of the fixed stars. Horizon, when applied to the earth, is either sensible or rational. Figs. 1, 2, 6, and 7.

The Sensible, or Visible Horizon, is the circle which bounds our view, where the sky appears to touch the earth or sea. The sensible horizon extends only a few miles; for example, if a man of six feet high were to stand on a large plane, or on the surface of the sea; the utmost extent of his view, upon the earth or the sea, would be only a very few miles.

The Rational, or true Horizon, is an imaginary plane, passing through the centre of the earth parallel to the sensible horizon. It determines the rising and setting of the sun, stars, and planets. Figs. 1 and 2.

The Wooden Horizon, B C, circumscribing the artificial globe, represents the rational horizon on the Earth. This horizon is divided into several concentric circles, arranged in the following order: One contains the thirty-two points of the compass, divided into half and quarter points. The degrees in each point are to be found in the amplitude circle. Another contains the twelve signs of the zodiac, with the figure and character of each sign; and another contains the days of the month answering to each degree of the sun's place in the ecliptic, and the twelve calendar months.

The Cardinal Points of the horizon are east, west, north, and south. The Cardinal Points in the heavens are the zenith, the nadir, and the points where the sun rises and sets. The Cardinal Points of the ecliptic are the equinoctial and solstitial points, which mark out the four seasons of the year; and the cardinal signs are—

♈ Aries, ♋ Cancer, ♎ Libra, and ♑ Capricorn.

The Zenith is a point in the heavens exactly over head, and is the elevated pole of our horizon. Fig. 2.

The Nadir is a point in the heavens exactly under our feet, being the depressed pole of our horizon, and the zenith, or elevated pole, of the horizon of our antipodes. Fig. 2.

The Pole of any circle is a point on the surface of the globe, ninety degrees distant from every part of the circle of which it is the pole. Thus the poles of the world are ninety degrees from every part of the equator; the poles of the ecliptic (on the celestial globe) are ninety degrees from every part of the ecliptic, and 23° 28′ from the poles of the equinoctial, consequently they are situated in the arctic and antarctic circles. Every circle on the globe, whether real or imaginary, has two poles diametrically opposite to each other. Figs. 1 and 2.

The Equinoctial Points are Aries and Libra, where the ecliptic cuts the equinoctial. The point Aries is called the vernal equinox, and the point Libra the autumnal equinox, When the sun is in either of these points, the days and nights on every part of the globe are equal to each other.

The Solstitial Points are Cancer and Capricorn. When the sun enters Cancer, it is the longest day to all the inhabitants on the north side of the equator, and the shortest day to those on the south side. When the sun enters Capricorn, it is the shortest day to those who live in north latitude, and the longest day to those who live in south latitude.

An Hemisphere is half the surface of the globe; for every great circle divides the globe into two hemispheres. The horizon divides the upper from the lower hemisphere in the heavens; the equator separates the northern from the southern on the earth; and the brass meridian, standing over any place on the terrestrial globe, divides the eastern from the western hemisphere. See figs. 2, 3, 4, and 5.

The Mariner's Compass is a representation of the horizon, and by seamen it is used to direct and ascertain the course of their ships. It consists of a circular brass box, which contains a paper card, divided into thirty-two equal parts, and fixed on a magnetical needle that always turns towards the north. Each point of the compass contains 11° 15′, or 11¼ degrees, being the 32d part of 360 degrees. *See* Compass.

The Variation of the Compass is the deviation of its points from the corresponding points in the heavens. When the north point of the compass is to the east of the true north point of the horizon, the variation is east; if it be to the west, the variation is west. The compass is used for setting the artificial globe north and south; but care must be taken to make a proper allowance for the variation.

The Latitude of a place, on the terrestrial globe, is its distance from the equator in degrees, minutes, or geographical miles, &c. and is reckoned on the brass meridian, from the equator towards the north or south pole. *See* Latitude.

The Quadrant of Altitude, E, fig. 6, a thin piece of brass divided upwards from 0 to 90 degrees, downwards from 0 to 18 degrees; when used, it is generally screwed to the brass Meridian. The upper divisions determine the distances of places on the earth, the distances of the celestial bodies, their latitudes, &c.; and the lower divisions are applied to finding the beginning, the end, and duration of twilight.

The Longitude of a place on the terrestrial globe, is the distance of the meridian of that place from the first meridian, reckoned in degrees, and parts of a degree, on the equator. Longitude is either eastward or westward, according as a place is to the east or west of the first meridian. No place can have more than 180 degrees, or half the circumference of the globe. *See* Longitude.

Hour Circles, are the the same as meridians. They are drawn through every fifteen degrees of the equator, each answering to an hour. The brass meridian and these circles always correspond.

A Parallel Sphere, fig. 4, is represented truly when the equator and rational horizon correspond. The poles are perpendicular to the horizon. A Direct or Right Sphere, fig. 5, is the reverse; the equator is at right angles with the horizon. An Oblique Sphere, fig. 3, is that position the earth has when the rational horizon cuts the equator obliquely, and hence it derives its name. All inhabitants on the earth (except those who live exactly at the poles, or at the equator) have this position of the sphere. The days and nights are of unequal lengths, the parallels of latitude being divided into unequal parts by the horizon.

Climate, is a part of the surface of the earth contained between two small circles parallel to the equator, and of such a breadth, that the longest day in the parallel nearest the pole, exceeds the longest day in the parallel of latitude nearest the equator, by half an hour, in the torrid and temperate zones, or by a month in the frigid zones; so that there are twenty-four climates between the equator and each polar circle, and six climates between each polar circle and its pole.

A Zone, is a portion of the earth's surface contained between any two circles parallel to the equator; and there are five zones. The Torrid Zone, extending from the tropic of Cancer to the tropic of Capricorn, is 46° 56′ broad. This zone was thought by the ancients to be uninhabited, because it is continually exposed to the direct rays of the sun; and such parts of the torrid zone as were known to them were sandy deserts, as the middle of Africa, Arabia, &c. and these sandy deserts extended beyond the left bank of the Indus, towards Agimere. The Two Temperate Zones. The north temperate zone extends from the tropic of Cancer to the arctic circle; and the south temperate zone from the tropic of Capricorn to the antarctic circle. These zones are each 43° 4′ broad, and were called temperate by the ancients, because meeting the sun's rays obliquely, they enjoy a moderate degree of heat. The Two Frigid Zones. The north frigid zone, or rather segment of the sphere, is bounded by the arctic circle. The north pole, which is 23° 28′ from the arctic circle, is situated in the centre of this zone. The south frigid zone is bounded by the antarctic circle, distant 23° 28′ from the south pole, which is situated in the centre of this zone. See fig. 2.

Amphiscii are inhabitants of the torrid zone. They are so called, because their shadows fall north or south at different times of the year. Heteroscii are the inhabitants of the temperate zones, because their shadows at noon fall only one way. The Periscii are those people who inhabit the frigid zones. They are so called, because their shadows, during a revolution of the earth on its axis, are directed towards every point of the compass. Antoeci are those who live in the same degree of longitude, and in equal degrees of latitude, but the one in north and the other in south latitude. Perioeci are those who live in the same latitude, but in opposite longitudes. Antipodes are those inhabitants of the earth who live diametrically opposite to each other, and consequently walk feet to feet.

The Crepusculum, or Twilight, is that faint light which we perceive before the sun rises, and after he sets. It is produced by the rays of light being refracted in their passage through the earth's atmosphere, and reflected from the different particles thereof. The twilight is supposed to end in the evening when the sun is eighteen degrees below the horizon.

The angle of position between two places on the terrestrial globe is an angle at the zenith of one of the places, formed by the meridian of that place, and a vertical circle passing through the other place, measured on the horizon from the elevated pole towards the vertical circle.

Rhumbs are the divisions of the horizon into thirty-two parts, called the points of the compass.

Problem 1.—*To find the latitude of any place.*—Rule. Turn the globe till the place comes to the graduated edge of the brazen meridian, and the degree on the meridian with which the place corresponds is the latitude north or south, as it may be north or south of the equator.

Example.—Thus the latitude of London is 51½ north, and of Lima 12° 1′ south. What are the latitudes of Athens, Bengal, the Cape of Good Hope, Cape Horn, Constantinople, Edinburgh, Ispahan, Madras, Moscow, Paris, Philadelphia, Prague, Stockholm, and Vienna? The answers to these are found from the respective places in the table at the words *Latitude* and *Longitude*.

Problem 2.—*To find the longitude of any place.*—Rule. Turn the globe till the place comes to the brazen meridian, and the degree on the equator intersected by the brazen meridian, shews the longitude from London.

Example.—The longitude of Madras is eighty degrees east: of Lisbon, nine degrees west. What are the longitudes of Amsterdam, Archangel, Babelmandel, Bengal, Dublin, Gibraltar, Jerusalem, and Quebec?

Problem 3.—*To find any place on the globe, having the latitude and longitude of that place given.*—Rule. Find the longitude of the given place on the equator, bring it to that part of the brass meridian which is numbered from the equator towards the poles; and then under the given latitude, on the brass meridian, you will find the place required.

Example.—1. What place has 151½° east longitude, and 34° south latitude? *Answ.* Botany Bay.

Problem 4.—*To find the difference of latitude of any two places.*—Rule. If the places are in the same hemisphere, bring each to the meridian, and subtract the latitude of the one from that of the other; if in different hemispheres, add the latitude of the one to that of the other, and the sum will shew the difference of latitude.

Examples.—1. What is the difference of latitude between Philadelphia and Petersburg? *Answ.* Twenty degrees.

2. What is the difference of latitude between Madrid and Buenos Ayres? *Ans.* Seventy-five degrees.

Problem 5.—*To find the difference of longitude between any two places.*—Rule. Bring one of the places to the brazen meridian, mark its longitude; then bring the other place to the meridian, and the number of degrees between its longitude and that of the first mark is the difference of longitude. When this sum exceeds 180 degrees, take from it 360, and the remainder will be the difference of longitude.

Examples.—1. What is the difference of longitude between Barbadoes and Cape Verd? *Answ.* 41° 48′.

2. What is the difference of longitude between Buenos Ayres and the Cape of Good Hope? *Answ.* 76° 50′.

3. What is the difference of longitude between Botany Bay and Owhyhee? *Answ.* 52° 45′, or 52¾°.

Problem 6.—*To find the distance between two places.*—Rule. When the distance is less than 90, lay the quadrant of altitude over both the places, so that the division marked O may be on one of the places; then the degree cut by the other place will shew the distance in degrees. Multiply these degrees by 69½, and the product will be the distance in English miles. The distance between two places, with the angle of position, may be found, at the same time, in the following manner:—1. Elevate the globe for one of the places, bring it to the meridian, screw the quadrant of altitude over it; then move the quadrant till it come over the other place, and observe what degree of it this last place cuts. Subtract this distance from 90 and the remainder will be the distance in degrees. The quadrant of altitude, on the horizon, will now shew the angle of position.

When the distance is greater than 90, find the antipodes of one of the places, and measure the distance between this and the other place with the quadrant of altitude. Subtract this distance from 180, and the remainder will be the whole distance required.

When the angle of position is required, this case may be performed thus: 1. Elevate the globe for the antipodes of one of the places, and having fixed the quadrant over it, bring its edge over the other place, and add the degree cut by it to 90, and the sum will be the distance required. 2. The quadrant will shew the position; only, W. must be read for E.; E. for W.; N. for S.; and S. for N. 3. What is the distance between London and Botany Bay?

154 distance in degrees.	154 distance in degrees.
60	69½
9240 geographical miles.	77
	1386
	924
	10703 English miles.

Problem 7.—*The hour being given at any place, to find what hour it is in any other part of the world.*—Rule. Bring the place at which the time is given to the meridian, set the index to the given hour, then turn the globe till the other place comes to the meridian, and the index will shew the time required.

Obs. The earth turns round on its axis from the *west* towards the *east*, and causes a different part of its surface to be successively presented to the sun. When the meridian of any place is directly opposite to the sun, it is then noon to all places on that meridian. Meridians towards the east come opposite to the sun sooner than those towards the west; and hence the people there have noon much sooner, and all the other hours of the day will be proportionably advanced. The earth takes 24 hours to turn on its axis, and the rate at which it turns every hour may be found, by dividing 360° by 24; the quotient, 1 , is the number of degrees the earth turns in an hour. Hence it is that a place lying 15° to the east of another, will have noon one hour sooner; if it is 30° or 45°, it will have noon two or three hours sooner than the other; and so on in the same proportion for all places further removed. Places that lie 15°, 30°, or 45°, to the west of that place at which it is noon, will have noon one, two, or three hours later; and so on in the same proportion.

Question for Exercise.—What is the hour at Pekin, when it is 9 *a. m.* at Lisbon? *Answ.* Twenty-two minutes after 5 *p. m.*

Calculation.—The difference of longitude is 125° 33′ = 8 hours 22 minutes; and, as Pekin is east of Lisbon, this must be added.

9 hours 0 minutes, *a. m.* given hour at Lisbon.
8 22 difference of time between the places.

17 22
12 0 subtracted.

Answ. 5 hours 22 minutes *p. m.*

Problem 8.—*To adjust the globe for the latitude, zenith, and sun's place.*—Rule. For *the latitude:* elevate the pole above the horizon according to the latitude of the place, and the globe will be adjusted for the latitude. For *the zenith:* screw the quadrant of altitude on the meridian at the given degree of latitude, counting from the equator towards the elevated pole, and the globe will be rectified for the zenith. For *the sun's place:** find the sun's place on the horizon, and then bring the place which corresponds thereto, found on the ecliptic, to the meridian, and set the hour-index to twelve at noon, then will the globe be adjusted for the sun's place.

Examples.—1. Thus to rectify for the latitude of London on the 10th of May. The globe is so placed, that the north pole shall be 51½ degrees above the north side of the horizon; then 51° will be found on the zenith of the meridian, on which the quadrant must be screwed. On the horizon, the 10th of May answers to the 20th of Taurus: find this on the ecliptic, bring it to the meridian, set the index to twelve, and the globe is rectified for the latitude, zenith, and sun's place, for the 10th of May.

2. Rectify the globe for London, Petersburgh, Madras, and Pekin, for the 24th of February.

3. Find the same sign and degree in the ecliptic on the surface of the globe, and this is the sun's place for that day at noon.

The sun's place, or, as it is otherwise termed, the *sun's longitude*, may be found for any day of the year in White's Ephemeris, or in the Nautica Almanack. In White's Ephemeris it is marked in the first column of the right-hand page of every month.

4. What is the sun's place for March 10th? *Answ.* ♓ 20° 7′.

5. What is the sun's place on the 4th of June? *Answ.* ♊ 13° 57′.

Problem 9.—*To find the sun's declination.*—Rule. Bring the sun's place for the given day to the brass meridian, and the degree over it will be the declination sought; or bring the day of the month marked on the analemma,† to the brass meridian, and the degree over it will be the declination as before. The sun's declination is given in the table, page 399, for every day in the year.

1. The declination of the sun being its distance north or south from the equator, this problem is exactly the same as that for finding the latitude of a place.

2. The greatest north declination, 23° 28′, is when the sun enters Cancer, June 21st, that being the greatest distance of the

---

* Find the day of the month on the horizon, and against it, in the adjoining circle, will be found the sign and degree in which the sun is for that day.

† The Analemma is properly an orthographic projection of the sphere on the plane of the meridian; but what is called the Analemma on the globe is a narrow slip of paper, the length of which is equal to the breadth of the torrid zone. It is pasted on some vacant place on the globe in the torrid zone, and is divided into months, and days of the month, corresponding to the sun's declination for every day in the year. It is divided into two parts; the right-hand part begins at the winter solstice, or December 21st, and is reckoned upwards towards the summer solstice, or June 21st, where the left-hand part begins, which is reckoned downwards in a similar manner, or towards the winter solstice. On Cary's globes the Analemma somewhat resembles the figure 8. It appears to have been drawn in this shape for the convenience of shewing the equation of time, by means of a straight line which passes through the middle of it. The equation of time is placed on the horizon of Bardin's globes.

ecliptic north of the equator. The greatest south declination, 23° 28′, is when it enters Capricorn, December 21st, that being the greatest distance of the ecliptic south of the equator.

Examples.—1. What is the sun's declination for March 10th? *Answ.* 3° 84′ south.

2. Also for January 31st? *Answ.* 17° 14 south.

3. Also, 1. April 23d? 2. August 12th? 3. August 1st? 4. March 5th? 5. July 23d? 6. October 19th?

Problem 10.—*To rectify the globe far the sun's place, and day of the month.*—Find the sun's declination for the given day, by the last problem. Then, if the declination be north, elevate the north pole as many degrees as are equal to it; if south, elevate the south pole. When the globe is rectified for the sun's place, and the sun brought to the zenith, the horizon will be the boundary of light and darkness; it will therefore be day with all those places above the horizon, and night with all those below it.

Examples.—1. Rectify the globe for the sun's place on June 4th. *Answ.* On June 4th the sun's declination is 22½° north; therefore the north pole of the earth must be elevated 22½° above the horizon.

2. Elevate the globe for the sun's place on October 6th. *Answ.* The sun's declination on October 6th is 5° south; hence the south pole of the earth must be elevated 5° above the horizon.

Problem 11.—*To find the sun's rising and setting for a given day, at a given place.*—Rule. Elevate the globe for the sun's declination; bring the given place to the meridian; set the index to twelve, and turn the globe till the given place comes to the eastern edge of the horizon; then the index will shew the time of the sun's rising. Next bring the given place to the western edge of the horizon, and the index will shew the hour at which the sun sets. If the hour circle have a double row of figures, make use of that which increases towards the *east*; the sun's rising and setting may then be found at once, by bringing the place only to the eastern edge of the horizon, for the index will point on one row to the hour of rising, and on the other (that which increases towards the *west*) to the hour of setting.

By this problem may be found the length of the day and night.—Double the time of the sun's setting, and it will give the length of the day.

Double the time of the sun's rising, and it will give the length of the night.

Examples.—1. Required the time of sun-rise and sun-set at London on the 1st of June.

2. What time does the sun rise and set at London on July 17th, and what is the length of the day and night?

Problem 12.—*A place being given in the north frigid zone, to find when the sun begins to appear above the horizon, and when to disappear; also the length of the longest day and night.*—Rule. Elevate the globe for the latitude; bring the ascending signs to the south point of the horizon; observe what degree of the ecliptic is cut by that point; find on the calendar, the day of the month answering to that degree; and this will be the time of the sun's beginning to appear above the horizon at the given place, which is the end of the longest night.

Bring the descending signs to the south point of the horizon, and the day in the calendar, answering to the degree of the ecliptic cut by this point, will be that on which the sun disappears; which is the beginning of the longest night.

Bring the ascending signs to the north point of the horizon, and the degree of the ecliptic, indicated as above, will shew when the sun begins to shine continually; which is the beginning of the longest day.

Bring the descending signs to the same point, and in the same manner it will be found when the sun ceases to shine continually, or the end of the longest day.

From the end of the longest night to the beginning of the longest day, and from the end of the longest day to the beginning of the longest night, the sun rises and sets daily.

Examples.—1. Whale Island, discovered by Mackenzie, lies in latitude 69° 14′ north: required the time when the sun first appears above the horizon, and when it disappears; also the length of the longest day and night there. *Answ.* 90° 0′ — 69° 14′ north = 20° 46′ co-latitude.

The two days when the sun's declination is 20° 46′ south, (of a contrary name to the latitude,) are January 17th and November 25th; on the former the sun first appears above the horizon, on the latter it disappears. The two days in which the sun's declination is 20° 46′ north, (of the same name with the latitude,) are May 24th and July 20th; the former is the beginning, and the latter the ending, of the longest day. Hence, at Whale Island, the sun first appears January 17th, and rises and sets daily till May 24th, a space of 127 days: it continues above the horizon from May 24th to July 20th; therefore the longest day there is equal to fifty-seven natural days. From July 20th it rises and sets daily till November 25th, 127 days, and never rises again till January 17th; its longest night is therefore equal to fifty-three days.

2. When does the sun begin to appear above the horizon at North Cape, in Lapland, latitude 72° north; when does it disappear? and how many days are the inhabitants without seeing the sun? *Answ.* The sun appears January 26, and rises and sets daily till May 15; after which time it continues above the horizon till July 29; then it rises and sets daily till November 16, when it entirely disappears till January 26; the length of the longest night is therefore equal to seventy-one days.

Problem 13.—*To find in what latitude, in the north frigid zone, the sun begins to shine, without setting, on any given day.*—Rule. Find the sun's declination on the given day, subtract it from 90°, and the remainder will be the latitude required. The given day must be between March 21st and June 21st. In the same manner it may be found in what latitude, in the south frigid zone, the sun begins to shine, without setting, on any given day between September 23d and December 21st.

Examples.—1. In what latitude does the sun begin to shine, without setting, on April 28d? *Answ.* 77° 31′ north.

2. In what latitude does the sun begin to shine, without setting, May 15th? *Answ.* 71° 1′ north.

Problem 14.—*Having the length of the longest day in any place, to find the latitude of that place.*—Rule. Bring the first of Cancer to the meridian, and set the index to twelve. Then turn the globe westward till the index point to the hour of setting, which is equal to half the length of the day. Raise or depress the pole, till the sun's place is exactly in the western horizon; then will the elevation of the pole be equal to the latitude of the place.

By this problem it may be found in what latitude any day is of a given length, by bringing the sun's place for the given day to the meridian, and proceeding as above.

Examples.—1. In what latitude is June 21st, sixteen hours long? *Answ.* Latitude 49° north.

2. In what latitude is June 21st, eighteen hours long? *Answ.* latitude 58½° north.

3. In what latitude is December 1st, fourteen hours long? *Answ.* latitude 32° 46′ south.

Problem 15.—*A place being given in the torrid zone, to find two days of the year, when the sun is vertical to that place.*—Rule. Bring the given place to the meridian, find its latitude, which mark; turn the globe round, and observe the two points of the ecliptic that pass under this mark. Look upon the calendar for the days corresponding to these points, and these days will be the answer required.

Otherwise, by the analemma drawn upon the globe, find the latitude of the given place, and bring the analemma to the meridian. Then directly below this latitude will be found, on the analemma, the two days required.

Examples.—On what days is the sun vertical to the following places?

1. Otaheite?.................. *Answ.* Jan. 30. and Nov. 11.
2. Rio Janeire?................ —— Jan. 2, and Dec. 9.

Obs The first of the above examples may be performed without the globe.

The latitude of Otaheite is about 17½ south, in White's Ephemeris, or in the table of the sun's declination, p. 399, for those two days on which the sun's declination is 17½ south, and they will be found to be about January 30, and November 11.

This example is proved thus: From November 11th to December 21st, there are forty days; and from December 31st to January 30th, are forty days: hence the number of days from the time when the sun is vertical, to the nearest solstice, is equal to the number of days from that solstice to the time when the sun is again vertical.

Problem 16.—*To find all those places in the torrid zone to which the sun is vertical on a given day.*—Rule. Find the sun's place for the given day, bring it to the meridian, mark the declination, and turn the globe round, when all those places which pass under that mark of the meridian, will have the sun vertical on the given day. By the analemma, bring the day of the month, marked upon the analemma, to the brazen meridian, and mark the declination; then the places will be found as above.

Examples.—To what places is the sun vertical on November 10th?—*Answ.* To Otaheite, the Great Cyclades, and New Hebrides, in the South Sea; Cape Grafton, in New South Wales; the Island of Madagascar; Monomotapa and Mataman, in Africa; Punta Gorda, in Brazil; and the southern parts of Amazonia and Peru, in South America.

2. To what places is the sun vertical on February 2d. *Answ.* To the same as in the last example.

Problem 17.—*The day, hour, and place, being given, to find at what places of the earth the sun is then rising and setting, where it is noon and midnight.*—Rule. Find the place to which the sun is vertical at the given hour, bring the same to the meridian, and adjust the globe to a latitude equal to the sun's declination. Then to all places under the *western* side of the horizon the sun is *rising;* to those above the *eastern* horizon the sun is setting; to all those under the upper half of the brazen meridian, it is *noon;* and to all those under the *lower* half, it is *midnight*.

Examples.—1. When it is fifty-two minutes past four o'clock in the morning at London, on the fifth of March, find all places of the earth where the sun is rising, setting, &c. &c. *Answ.* The sun's declination will be found to be 6¼° south; therefore, elevate the south pole 6¼° above the horizon. The given time being seven hours eight minutes before noon, (=12 h.—4h. 52m.) the globe must be turned towards the *west* till the index has passed over seven hours eight minutes. Let the be be fixed in this position; then,

The sun is rising at the western part of the White Sea, Petersburg, the Morea in Turkey, &c.

Setting at the eastern coast of Kamschatka, Jesus Island, Palmerston Island, &c. between the Friendly and Society Islands.

Noon at the lake Baikal in Irkoutsk, Cochin China, Cambodia, Sunda Islands, &c.

Vertical at Batavia.

Morning twilight at Sweden, part of Germany, the southern part of Italy, Sicily, the western coast of Africa along the Æthiopian Ocean, &c.

Evening twilight at the north-west extremity of North America, the Sandwich Islands, Society Islands, &c.

Midnight at Labrador, New York, western parts of St. Domingo, Chili, and the western coast of South America.

Day at the eastern part of Russia in Europe, Turkey, Egypt, the Cape of Good Hope, and all the eastern part of Africa, almost the whole of Asia, &c.

Night at the whole of North and South America, the western part of Africa, the British Isles, France, Spain, Portugal, &c.

2. When it is four o'clock in the afternoon at London on the 25th of April, where is the sun rising, setting, &c. &c.? *Answ.* The sun's declination being 13° north, the north pole must be elevated 13° above the horizon; and as the given time is four o'clock in the afternoon, the globe must be turned four hours towards the *east;* when the sun will be *rising* at Owhyhee, &c. *setting* at the Cape of Good Hope, &c.; it will be *noon* at Buenos Ayres, &c.; the sun will be *vertical* at Barbadoes, and following the problem, all the other places are readily found.

Problem 18.—*To shew, by the globe, the cause of day and night.*—The sun shines upon the earth, and illuminates that half only which is turned towards him; and the other half is in darkness.

But, as the earth turns round on its axis, from west to east, once in twenty-four hours, every meridian upon the earth will, in that time, successively be presented to the sun, and be deprived of its light again.

Elevate the globe for the sun's declination, so that the sun may be in the zenith, and the horizon will be the terminator, or boundary circle, of light and darkness; that half of the earth above the horizon enjoys light, that half below the horizon will be in darkness.

Put a patch upon a globe to represent any place, turn the globe round from west to east, and when the place comes to the western side of the horizon, the sun appears to the inhabitants of that place to be rising in the east; but it is more properly the inhabitants of that place rising in the west. Go on to turn the globe round, and the place will ascend higher towards the meridian in a contrary direction.

When the place has arrived at the meridian it will then be noon there, and the sun will be at his greatest altitude for that day.

Continue to turn the globe, and the place will gradually recede from the meridian, and decline towards the eastern horizon, which will cause the appearance of the sun descending towards the west When the place has arrived at the eastern horizon, as it is then going below the boundary of light and darkness, the sun will appear to be setting in the west.

The place being now at a greater distance than 90° from that point where the sun is vertical, is deprived of his light, and continues in darkness till by the revolution of the earth it arrives again at the western horizon, when the sun will appear to rise as before.

The sun is obviously rising at the same time to all places on the western side of the horizon, and setting at the same time to all places on the eastern side of the horizon.

Problem 19.—*To shew, by the globe, the cause of the variety of the seasons.*—When the sun is in the equator, the horizon will represent the terminator, or boundary circle of light and darkness; and the poles being made to coincide with it, we shall have a fair representation of the two seasons, spring and autumn; for its rays then extending 90° every way from the vertical point, both poles will be illuminated.

When the sun is in the tropic of Cancer, being 23½° farther to the north than before, his rays will extend 23½° beyond the north pole on the opposite meridian: they will not, however, reach the south pole by 23½°, they will extend to the antarctic only, being 90° distant from the tropic of Cancer: hence, to make the horizon the terminator in this case, the north pole must be elevated 23½° above the horizon, and we shall have the summer season to Europeans.

When the sun is in the tropic of Capricorn, the reverse of this takes place; for the sun's rays then extend 23½° beyond the south pole on the opposite meridian, and only as far north as the arctic circle: hence, to make the horizon the terminator in this case, the south pole must be elevated 23½° above the horizon, and we shall have the winter season to Europeans.

The problems thus given are only to be considered as specimens of what may be performed. On the terrestrial globe Butler describes fifty-seven, while on the celestial sphere the number and variety are still much greater. Combined together, they furnish a source of instructive amusement, which but few instruments within the compass of human invention can surpass. The exercise is calculated to enlarge the mind, and awaken it to serious and rational contemplations; and in the present day, to be wholly ignorant of their use, is a sure symptom of a defective education.

The first person who constructed a globe or sphere, is said to have been *Anaximander*, a philosopher of Miletus, the capital of Ionia, in Asia Minor. He was born 610 years before Christ, and is reputed to have been the inventor of maps and dials. Since his days, many improvements have been made in their construction and appendages, and much room still remains for the exercise of ingenuity.

Among the remarkable globes which have appeared, that of Gottorp in the academy of sciences of Petersburgh is worthy of notice. This is a large concave sphere *eleven feet* in diameter, containing a table, and seats for twelve persons, to whom the inside surface represents the visible phenomena of the heavens. The stars are distinguished by gilded nails, according to their respective magnitudes, and arranged in groups as the different constellations require. The outside is a terrestrial globe, representing the land and water on the surface of the earth. It is called the Globe of Gottorp, from being substituted for one originally made in that place, which, with inconceivable labour, was conducted upon rollers and sledges over snow and through forests to Riga, and thence by sea to Petersburgh. In 1751, it was consumed by fire, and from its iron plates and materials, the present globe was made.

In the lower room of the king's library at Paris, there are two globes nearly equal in dimensions to that at Petersburgh, but much inferior in utility, the globe of Gottorp combining in one, all that is exhibited by both the others.

But large as these globes are, they become diminutive when compared with the sphere constructed by the late Dr. Long. This, he tells us, is *eighteen feet* in diameter; and it will enable thirty persons to sit within its concavity, without any inconvenience. The entrance is over the south pole by six steps. This wonderful machine stands in Pembroke Hall, in the university of Cambridge. All the constellations and stars of the northern hemisphere, visible at Cambridge, are painted upon plates of iron, which, joined together, form one concave surface. Unhappily, it is now very much damaged. Part of the sheathing is destroyed, and the remainder is covered with rust and verdigrise. This neglected state of an ingenious and useful piece of workmanship, reflects considerable disgrace upon those whose duty it is to keep it in repair. But the disgrace must be heightened into ignominy, if the report be true, that the interest of £200, Bank annuities, was bequeathed by Dr. Long, to keep the instrument and place in good order. This truly scientific gentleman was a native of Norfolk, and died in 1770, aged ninety-one.

The Celestial Globe. *See Plate.—Definitions: Obs.* The general definitions given of the terrestrial globe apply also to the celestial, the various circles of which are more aptly illustrated by the—

Armillary Sphere,* *(see the Plate,)* is well adapted to give youth just notions of those imaginary circles which astronomers have applied to what is vulgarly called the *concave sphere of the heavens;* but by means of those circles, we investigate, with the nicest accuracy, the motions of the celestial bodies, and thus the communication of a sublime science is facilitated.

There are six great circles of the sphere, which require particular attention; but which the reader is now acquainted with: they are, the horizon, the meridian, the equator, the ecliptic, the equinoctial colure, and the solstitial colure.

The sphere is contained in a frame, on the top of which is a broad circle, representing the meridian.

It is suspended on two pins, at opposite points of the meridian. These pins are a continuation of the axis of the sphere both ways, and as the sphere turns round upon them, they are considered as poles, *north* and *south.*

The *equator* goes round the sphere exactly in the middle between the two poles.

The *ecliptic*, the *colures*, the *tropics*, and *polar* circles, have been already defined, and are easily discovered.

The horizon is graduated according to the division of the circle into quadrants and degrees; and to refer celestial objects to the horizon, we have also the points of the compass laid down. Hence the amplitude, or distance, of heavenly bodies, from the east and west points, and their azimuth, or distance from the meridian, are reckoned on the horizon of the armillary sphere.

The graduation of the equator enables us to fix the *right ascension* of celestial, and the *longitude* of terrestrial, objects.

The graduation of the ecliptic serves to indicate, in the armillary sphere, the latitude and longitude of celestial bodies.

The colures are, in a manner, the limits of the year, pointing out the seasons by their two opposite points of the ecliptic.

The *hour circle* tells us in what time any motion of the earth, in the centre, is performed.

In fine, many details of the science may be pleasingly and popularly illustrated by this contrivance.

The Appearances of the Stars in the Heavens illustrated by the Armillary Sphere.—By placing a small patch of paper on the different circles to represent stars, we perceive, that those which are furthest from the poles will describe the greatest circles; and that the greatest circles are described by those stars situated in the *celestial equator.* A star has acquired its greatest elevation when it comes to the upper semicircle of the meridian, and its greatest depression when it is at the lower circle of the meridian: the meridian bisects its arc of apparition. Some circles of revolution are wholly above, others entirely below, the horizon; therefore the patches on those circles shew us which stars descend below, or which never ascend above, the horizon. And any object, whose circle of revolution is on the same side of the equator with the elevated pole, is longer visible than it is invisible; the contrary holds true if it be on the other side of the equator.

The following definitions are more immediately applicable to the celestial globe.

The declination of the sun, of a star, or planet, is its distance from the equinoctial, northward or southward. When the sun is in the equinoctial he has no declination, and enlightens half the globe from pole to pole. As he increases in north declination he gradually shines farther over the north pole, and leaves the south pole in darkness: in a similar manner, when he has south declination, he shines over the south pole, and leaves the north pole in darkness. The greatest declination the sun can have is 23° 28′; the greatest declination a star can have is 90°, and that of a planet 30° 28′ north or south.

The latitude of a star, or planet, is its distance from the ecliptic, north or south, reckoned towards the pole of the ecliptic, on the quadrant of altitude. Some stars situate in and about the pole have 90° of latitude; the planets have only 8°, and the sun being always in the ecliptic has no latitude.

The longitude of a star, or planet, is reckoned by the degrees of the ecliptic, from the point Aries round the globe. On the celestial globe the longitude of the sun corresponds with the sun's place on the terrestrial globe.

The right ascension of the sun, or a star, is that degree of the equinoctial which rises with the sun, or a star, in a right sphere, and is reckoned from the equinoctial point Aries eastward round the globe.

Oblique ascension of the sun, or a star, is that degree of the equinoctial which rises with the sun, or a star, in an oblique sphere, and is likewise counted from the point Aries eastward round the globe.

Oblique descension of the sun, or a star, is that degree of the equinoctial which sets with the sun, or a star, in an oblique sphere.

The ascensional or descensional difference, is the difference between the right and oblique ascension, or the difference between the right and oblique descension: and, with respect to the sun, it is the time he rises before six in the spring and summer, or sets before six in the autumn and winter.

The angle of position of a star is an angle formed by two great circles intersecting each other in the place of the star, the one passing through the pole of the equinoctial, the other through the pole of the ecliptic.

The poetical rising and setting of the stars, is so called because the ancient poets referred the rising and setting of the stars to the sun.

When a star rose with the sun, or set when the sun rose, it was said to rise and set *cosmically.* When a star rose at sunsetting, or set with the sun, it was said to rise and set *achronically.* When a star first became visible in the morning, after having been so near the sun as to be hid by the splendour of his rays, it was said to *rise heliacally*; and when a star first became invisible in the evening, on account of its nearness to the sun, it was said to set *heliacally.*

A Constellation is an assemblage of stars on the surface of the celestial globe, circumscribed by the outlines of some assumed figure, as a *bull*, a *bear*, a *lion*, &c. This division of the stars into constellations direct us to any part of the heavens where a particular star is situated.

The zodiacal constellations are 12 in number; the *northern* constellations 41, and the *southern* 46, making in the whole 99. The largest stars are called stars of the first magnitude. Those of the sixth magnitude are the smallest that can be seen by the naked eye. The figures on the left hand of the annexed tables shew the number of stars in each constellation; R denotes right ascension, D declination of the middle of the several constellations, for the ready finding them on the globe. The modern constellations are distinguished from the ancient by a star.

---

* So called because it consists of a number of *rings* of brass, which the old Romans named *armillæ,* from their resemblance, perhaps, to bracelets, or rings for the arms.

The Contents of the Celestial Globe, and the Maps of the Heavens, with the Names of the Signs and Constellations, and of the Principal Stars in each, with their Magnitudes.

		R. Asc.	Dec.		No. of Stars.
	1. THE SIGNS OF THE ZODIAC.				
Spring ♈	Aries, *the Ram*, Arietis 2	30	22	N	66
♉	Taurus, *the Bull*, Aldebaran 1, the Pleiades, the Hyades	65	16	N	141
♊	Gemini, *the Twins*, Castor 1, Pollux 2	111	52	N	85
Summer. ♋	Cancer, *the Crab*, Acubene 4	128	20	N	83
♌	Leo, *the Lion*, Regulus, or Cor Leon.s 1, Deneb 2	150	15	N	95
♍	Virgo, *the Virgin*, Spica Virginis 1, Vindemiatrix 2	192	5	N	110
Autumn. ♎	Libra, *the Balance*, Zubenich Meli 2	226	8	S.	51
♏	Scorpio, *the Scorpion*, Antares 1	244	26	S.	44
♐	Sagittarius, *the Archer*	285	35	S.	69
Winter. ♑	Capricornus, *the Goat*	310	20	S.	51
♒	Aquarius, *the Water-bearer*, Scheat 5	335	4	S.	108
♓	Pisces, *the Fishes*	5	10	N	113
	II. THE NORTHERN CONSTELLATIONS.				
1	Andromeda, Mirac 2, Almaach 2	15	35	N	66
2	Aquila, *the Eagle*, with Antinöus, Altair 1	295	8	N	71
* 3	Canes Venatici, or Asterion and Chara*, *the Greyhounds*	200	40	N	25
* 4	Auriga, *the Charioteer*, or *Waggoner*, Capella 1	75	45	N	66
* 5	Böotes, Arcturus, Mirac 3	212	20	N	54
* 6	Camelopardalus*, *the Camelleopard*	68	70	N	58
* 7	Caput Medusæ, *the Head of Medusa*, and Perseus	44	40	N	59
* 8	Cassiopeia, Schedar 3	12	60	N	55
* 9	Cepheus, Alderamin 3	338	65	N	35
* 10	Cerberus*, *the Three-headed Dog*, and Hercules	271	22	N	
11	Coma Berenicis, *Berenice's Hair*	185	26	N	43
12	Cor Caroli*, Charles's Heart	191	39	N	3
13	Corona Borealis, *the Northern Crown*, Alphacca 2	235	30	N	21
* 14	Cygnus, *the Swan*, Deneb Adige 1	308	42	N	81
15	Delphinus, *the Dolphin*	308	15	N	18
16	Draco, *the Dragon*, Rastaben 2	270	66	N	80
17	Equulus, *the Little Horse*	316	5	N	10
18	Frederick's Ehre, *Frederick's Glory*			N	
* 19	Hercules (*see Cerberus*) Ras Algethi 1	245	22	N	113
* 20	Lacerto, *the Lizard*	336	43	N	16
21	Le Messier*				
* 22	Leo Minor*, *the Little Lion*	150	55	N	53
* 23	Lynx*, *the Lynx*	111	50	N	44
24	Lyra, *the Harp*, Vega or Wega 1	283	38	N	22
25	Mons Menalus, *the Mountain Menalus*	225	5	N	11
26	Musca*, *the Fly*	40	27	N	6
27	Pegasus, *the Flying Horse*, Markab 2, Scheat 2	340	14	N	89
* 28	Perseus (*see Cap. Med.*) Algenib 2, Algol 2	46	49	N	
29	Sagitta, *the Arrow*	295	18	N	18
30	Scutum Sobieski*, *Sobieski's Shield*	275	10	N	8
31	Serpens, *the Serpent*	235	10	N	64
32	Serpentarius vel Ophiuchus, the *Serpent-bearer*, Ras Alphagus 2	250	13	N	74
33	Taurus Poniatowski*, *the Bull of Poniatowski*	275	7	N	7
34	Taurus Regalis*, *the Royal Bull*				
35	Triangulum, *the Triangle*	27	32	N	11
36	Triangulum Minus, *the Little Triangle*	31	29	N	5
37	Tubus Herschelii Major, *Herschel's Great Telescope*				
* 38	Ursa Major, *the Great Bear*, Dubhe 1, Alioth 2, Benetnach 2	153	60	N	87
* 39	Ursa Minor, *the Little Bear*, Polar Star or Abrukabah 2	236	75	N	24
	Constellations, &c. continued.				
40	Vulpecula et Anser*, *the Fox and Goose*	300	25	N	37
* 41	Taraudus*, *the Rein Deer*	30	75	N	10
	III. THE SOUTHERN CONSTELLATIONS.				
1	Apus, vel Avis Indica*, *The Bird of Paradise*	252	75	S.	11
2	Ara, *the Altar*	255	55	S.	9
* 3	Argo Navis, *the ship Argo*, Canopus 1	115	50	S.	64
4	Brandenburgium Sceptrum*, *the Sceptre of Brandenburgh*	67	15	S.	3
5	Canis Major, *the Great Dog*, Sirius 1	105	20	S.	13
6	Canis Minor, *the Little Dog*, Procyon 1	110	5	S.	14
* 7	Centaurus, *the Centaur*	200	50	S.	35
8	Cetus, *the Whale*, Mencar 2	25	12	S.	97
9	Chamæleon*, *the Cameleon*	175	78	S.	10
10	Circinus*, *the Compasses*	222	64	S.	4
* 11	Columba Noachi*, *Noah's Dove*	85	35	S.	10
* 12	Corona Australis, *the Southern Crown*	278	40	S.	12
13	Corvus, *the Crow*, Algorab 3	185	15	S.	9
* 14	Crater, *the Cup or Goblet*, Alkes 3	168	15	S.	31
15	Crux*, *the Cross*	183	60	S.	6
16	Dorado or Xiphias*, *the Sword Fish*	75	62	S.	7
17	Equileus Pictorious*, *the Painters' Easel*	84	55	S.	8
* 18	Eridanus, *the River Po*, Acherner 1	60	10	S.	84
19	Fornax Chemica*, *the Furnace*	42	30	S.	14
20	Grus*, *the Crane*	330	45	S.	13
21	Horologium*, *the Clock*	40	60	S.	12
22	Hydra, *the Water Serpent*, Cor Hydræ 1	139	8	S.	60
23	Hydrus, *the Water Snake*	28	68	S.	10
24	Indus*, *the Indian*	315	55	S.	12
25	Lepus, *the Hare*	80	18	S.	19
* 26	Lupus, *the Wolf*	230	45	S.	24
27	Machina Pneumatica*, *the Air Pump*	150	32	S.	3
* 28	Microscopium*, *the Microscope*	315	35	S.	10
29	Monoceros*, *the Unicorn*	110	0	S.	31
30	Mons Mensæ*, *the Table Mountain*	76	72	S.	30
31	Musca Australis, vel Apis, *the Southern Fly* or *Bee*	185	68	S.	4
* 32	Norma, vel Quadra Euclidis*, *Euclid's Square*	242	45	S.	12
33	Octans Hadleianus*, *Hadley's Octant*	310	80	S.	43
* 34	Officina Sculptoria*, *the Sculptor's Shop*	3	38	S.	12
35	Orion, Betelgeux 1, Rigel 1, Bellatrix 2	80	0	S.	78
36	Pavo*, *the Peacock*	302	68	S.	14
37	Phœnix*	10	50	S.	13
38	Piscis Notus vel Australis, *the Southern Fish*, Fomalhaut 1	335	30	S.	24
39	Piscis Volans*, *the Flying Fish*	127	68	S.	8
40	Praxiteles, vel Cela Sculptoria*, *the Engraver's Tools*	68	40	S.	16
41	Pyxis Nautica*, *the Mariner's Compass*	130	30	S.	4
42	Reticulus Rhomboidalis*, the *Rhomboidal Net*	62	62	S.	10
43	Robur Caroli, *Charles's Oak*	159	50	S.	12
44	Sextans*, *the Sextant*	145	0	S.	41
45	Solitaire, *an Indian Bird*				
46	Telescopium, *the Telescope*	278	66	S.	
47	Psalterium Georgianum*, *the Georgian Psaltery*				
48	Touchan, *the American Goose*	359	66	S.	9
49	Tubus Herschelii Minor*, *Herchell's Less Telescope*				
50	Triangulum Australis*, *the South* △	218	65	S.	5
51	Xiplias, (*see Dorodo*)	75	62	S.	
52	Montgolfier's Balloon				
53	The Press of Guttenberg				
54	Le Chat, *the Cat*				

Note. The constellations 18, 21, 34, 37, in the northern, and 45, 47, 52, 53, and 54, in the southern hemisphere, are inserted because foreign astronomers have given them a place in the heavens, though our British globe makers have not yet engraven them on their plates. They are to be found, however, in the maps of Dr. Jamieson's *Cœlestial Atlas.*

The ancients divided the stars into different groups, called *constellations*, and gave particular names to each, which names the greater part of them have hitherto retained. The *Pleiades* and *Orion* are mentioned in the sacred writings by *Job*, and *Homer* and *Hesiod* describe several constellations by names which are now in general use.

A knowledge of the principal constellations in the heavens will be an useful acquisition to the student, and this may be obtained by noting the time when they come to the meridian, that is, to the south.

There are few persons who are unacquainted with the seven (*six*) stars called the *Pleiades*, or the beautiful constellation of *Orion*. The Pleiades come to the meridian of London about an hour before Aldebaran, and Orion culminates an hour after that star; and since the diurnal difference of time of a star's culminating is nearly equal to the diurnal difference of the sun's right ascension, *viz.* about four minutes; a star will rise, come to the meridian, and set, nearly four minutes earlier every day, or about two hours in a month.

A TABLE *of the Time of Culminating of the Zodiacal Constellations on the first Day of every Month, and the Semi-diurnal Arc at London.—N. B. The Time is reckoned from Noon to Noon.*

Zodiacal Constellations.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	S. Dior. Arc.
Aries, *Arietes, a.*	7¼	5	3¼	1¼	23½	21½	19	17	15	13¼	11½	9½	8¼ H.
Taurus, *Aldebaran, a.* ..	9¾	7½	5¾	3¾	1¾	23¾	21¾	19¾	17½	16¾	14	11¾	7½ H.
Gemini, *Castor, a.*	12½	10½	8¾	6¾	4¾	2¾	12¾	22½	20½	18¾	17	15	9¾ H.
Cancer, *Acubene, a.*	14	11¾	10¼	8¼	6½	4¼	2	12	22	20¼	18½	16½	7¼ H.
Leo, *Cor Leonis, a.*	15¼	13	11¼	9¼	7½	5½	3½	1¼	23¼	21¼	19½	17½	7½ H.
Virgo, *Spica, a.*	18½	16¼	14½	12½	10¾	8½	6½	4¾	2½	12¾	22¾	20½	5¼ H.
Libra, —— *a.*	19¾	17½	15¾	14	12¼	10	8	6	4¼	2¼	12¼	10¼	4¾ H.
Scorpio, *Antares, a.*	21½	19¾	17½	15½	13¾	11¾	9¾	7¾	5¾	3¾	2	23¾	3½ H.
Sagittarius, *Bow, δ.*	23¼	21¼	19¼	17¼	15½	13½	11½	9½	7½	5½	3¾	1¾	3 H.
Capricornus, *Horn, β.* ..	1½	23	21¼	19¼	17½	15½	13½	11¼	9½	7½	5¾	3¾	4¾ H.
Aquarius, *R. Should. a.*	3¼	1	23¼	21¼	19¼	17¼	15¼	13¼	11¼	9½	7½	5½	5¾ H.
Pisces, *String, a.*	7	4¾	3	1	23¼	21¼	18¾	16¾	14¾	13	11½	9¼	6¼ H.

Problems performed by the Celestial Globe.—Problem 1.—*To find the right ascension and declination of the sun, or a star.*—Rule. Bring the sun, or star, to that part of the brass meridian numbered from the equinoctial towards the poles, and the degree on the brass meridian is the declination, and the right ascension will be indicated by the degree on the equinoctial, between the brass meridian and the point Aries. Or place both the poles of the globe on the horizon, bring the sun or star to the eastern part of the horizon; then the number of degrees which the sun or star is northward or southward of the east, will be the declination north or south; and the degrees on the equinoctial, from Aries to the horizon, will be the right ascension.

Examples. 1. Required the right ascension and declination of *a Dubhe*, in the back of the Great Bear.—*Answer.* Right ascension 162° 49′, declination 62° 48′ N.

Problem 2.— *To find the latitude and longitude of a star.*—Rule. Place the upper end of the quadrant of altitude on the north or south pole of the ecliptic, according as the star is on the north or south side of the ecliptic, and move the other end till the star comes to the graduated edge of the quadrant; the number of degrees *between* the ecliptic and the star is the latitude; and the number of degrees *on* the ecliptic, reckoned eastward from the point Aries to the quadrant, is the longitude. Or, elevate the north or south pole 66½° above the horizon, according as the given star is on the north or south side of the ecliptic; bring the pole of the ecliptic to that part of the brass meridian numbered from the equinoctial towards the pole; the ecliptic will then coincide with the horizon: screw the quadrant of altitude upon the brass meridian over the pole of the ecliptic; keep the globe from revolving, and move the quadrant till its graduated edge comes over the given star; the degree on the quadrant cut by the star is its latitude; and the sign and degree on the ecliptic cut by the quadrant shew its longitude.

Examples. 1. Required the latitude and longitude of *a Aldebaran* in Taurus?—*Answ.* Latitude 5° 28′ S. longitude 2 signs 6° 53′; or 6° 53′ in Gemini.

Problem 3.—*The right ascension and declination of a star, the moon, a planet, or of a comet, being given, to find its place on the globe.*- Bring the given degrees of right ascension to that part of the brass meridian numbered from the equinoctial towards the poles; then, under the given declination on the brass meridian, you will find the star, or the place of the planet.

Examples. 1. What star has 261° 29′ of right ascension, and 52° 27′ north declination? *Answ.* β in Draco.

2. On the 20th of August, 1805, the moon's right ascension was 91° 3′, and her declination 24° 48′; to find her place on the globe at that time. *Answ.* In the milky way, a little above the left foot of Castor.

Problem 4.—*The latitude and longitude of the moon, a star, or a planet given, to find its place on the globe.*—Place the division of the quadrant of altitude marked O, on the given longitude in the ecliptic, and the upper end on the pole of the ecliptic; then under the given latitude, on the graduated edge of the quadrant, you will find the star, or place of the moon, or planet.

Examples. 1. What star has 0 signs 6° 16′ of longitude, and 12° 36′ N. latitude. *Answ.* γ in Pegasus.

2. On the fifth of June, 1820, at midnight, the moon's longitude was 5ˢ 15° 6′, and her latitude 1° 45′ N.; find her place on the globe.

Problem 5.—*To find the rising, setting, and culminating of any star,—its continuance above the horizon,—its oblique ascension and descension,—and its eastern and western amplitude, for any given day and place.*—Rectify the globe, and bring the given star to the eastern part of the horizon, the index will shew the hour of rising; the degree of the equinoctial that rises with the star is its oblique ascension; and the distance of the star from the east point of the horizon is its eastern or rising amplitude.

When the star is brought to the meridian, the index will shew the time of culminating.

Bring the star to the western quarter of the horizon, and its setting, oblique descension, and western amplitude, will be found in the same manner as its rising, eastern amplitude, and oblique ascension.

The number of hours from rising to setting will be the time of its continuance above the horizon.

Examples. 1. On the ninth of February, when it is nine o'clock in the evening at London, what stars are rising, what stars are setting, and what stars are on the meridian.—*Answ.* Alphacca, in the northern Crown, is rising; Arcturus and

Mirach in Bootes, just above the horizon; Sirius on the meridian; Procyon and Castor and Pollux, a little east of the meridian. The constellations Orion, Taurus, and Auriga, a little west of the meridian; Markab in Pegasus, just below the western edge of the horizon, &c.

2. On the 20th of January, at two o'clock in the morning, at London, what stars are rising, what stars are setting, and what stars are on the meridian? *Answ.* Vega in Lyra, the head of the Serpent, Spica Virginis, &c. are rising; the head of the Great Bear, the claws of Cancer, &c. on the meridian; the head of Andromeda, the neck of Cetus, and the body of Columba Noachi, &c. are setting.

3. When does Sirius rise at London, on March 14; at what time comes it to the meridian, and set; how long does it continue above the horizon; what are its oblique ascension and descension, and its eastern and western amplitude?

Answ. Rises at	2h	24m.	*p.m.*
Culminates	6	57	*p.m.*
Sets	11	30	*p.m.*
Above the horizon	9	6	
Oblique ascension	120°	47′	
Oblique descension	77	17	
Amplitude	27	0 S.	

4. Required the same for Fomalhaut, at the Cape of Good Hope, on December 10th?

Answ. Rises	10h	0m.	*a.m.*
Culminates	5	30	*p.m.*
Sets	1	0	*a.m.*
Above the horizon	15	0	
Oblique ascension	317°	0′	
Oblique descension	5	0	
Amplitude	38	0 S.	

Problem 6.—To represent the face of the heavens for any given day and hour, in any given latitude.—Adjust the globe as in the preceding problems, by bringing the sun's place to the meridian, putting the index to 12, and then turning the globe to the given hour; and the stars in the heavens will appear exactly in the same situations as they are upon the globe.

Examples. 1. Required the situation of the stars for the latitude of Newcastle, on October 6th, at eight o'clock in the evening. In this survey we commence at the north point of the horizon, and proceed eastward, noticing the different constellations, and the relative situation of the stars in these constellations.

The first star which strikes the eye of the observer, in the north-east part of the heavens, is Capella, in the constellation Auriga, or the waggoner: it is of the first magnitude, of the altitude of 22°, or nearly the fourth part of the distance from the horizon to the zenith. There are two stars of the second magnitude, which form with Capella a triangle: the star which forms the short side of the triangle is in the right shoulder of Auriga, and is marked β; it lies at the distance of about 8° from Capella, further to the north; its altitude is 18°; the star forming the longer side of the triangle is in the Bull's northern horn: its distance from Capella is not more than 25°; its altitude not more than 5°; azimuth N. E. There are three stars of the fourth magnitude, a little to the south of Capella, that bear the name of the Kids.

If a line be drawn through the two stars that form the upper side of the triangle, and continued to the horizon, it will point out Castor, α, in Gemini, just rising; azimuth, E. N. E.: it is between the first and second magnitude. The other stars in this constellation have not yet risen.

A line, drawn between Castor and Capella, and continued higher in the heavens, will point out Perseus, in which there are three stars, one of the second magnitude, α, named Algenib, and two of the third magnitude, one on each side of Algenib, at the distance of about 5°; they form a line, a little curved on the side next Auriga. The altitude of Algenib is 37°; azimuth, N. E. by E.

A little to the south of Perseus is the head of Medusa, which Perseus is holding in his hand. Besides two or three smaller stars, it contains one of the second, and one of the third magnitude: the name of the brightest is Algol; altitude 33°; azimuth, E. N. E. Algol is only 10° distant from Algenib.

Directly below the head of Medusa, about 14° above the horizon, are the Pleiades, or Seven Stars; they are situated in the shoulder of Taurus, and are so easily known, that no description is necessary. Aldebaran, a star of the first magnitude, which forms the eye of Taurus, is just rising; azimuth, E. N. E. A vertical circle, drawn through Algol, will point to it. There are two stars of the third magnitude, and several smaller, very near Aldebaran, which form with it a triangle. The whole cluster is called the Hyades.

A line drawn from Aldebaran through Algol, and continued to the zenith, will direct to Cassiopeia. This contains five stars of the third magnitude, besides several of the fourth: it is in form something like the letter Y, or, as some think, an inverted chair. It is situated above Perseus, within 30° of the zenith. The altitude of the brightest star α, called Schedar, is 60°; azimuth, E. N. E.

Below Cassiopeia, and west of Perseus, is Andromeda, which contains three stars of the second magnitude. A line from Algenib, parallel to the horizon, towards the south, will pass very near these three stars; and as they are all of the same magnitude, and placed nearly at the same distance of 15° from each other, they may easily be known. The name of the star nearest Perseus, and which is in the foot of Andromeda, marked γ, is Almaack: its altitude is 49°; azimuth, E. N. E. The name of β, in the girdle, is Mirach; its altitude 44°; azimuth, E. The altitude of α, in the head of Andromeda, is 46°; azimuth E. S. E.

About 18° below Mirach are two stars in Aries, not more than 5° distant from each other, forming with Mirach an isosceles triangle: the most eastern star α, is of the second magnitude; the other, β, of the third, attended by a smaller star, marked γ, of the fourth magnitude. A line drawn from Mirach, perpendicular to the horizon, will pass between the two, and, besides, will point to a star of the second magnitude, directly E. not 3° above the horizon.

The star is the first of Cetus, marked α, and is of the second magnitude; it is named Menkar: a line, drawn from Capella through the Pleiades, will also point to it. Cetus is a large constellation, and contains eight stars of the third magnitude; they all lie to the west of Menkar; β, a star in the tail, is more than 40° degrees distant from it. The azimuth of β is S. E. by E.; altitude nearly the same as Menkar.

The constellation Pisces is situated next to Aries; it contains one star of the third magnitude, marked α; its altitude is 10°; azimuth, E. by S.; it is distant from Menkar 15°. A line drawn from Almaack, through α in Aries, will point to it.

If we return again to α, in the head of Andromeda, we shall find three other stars nearer the meridian, which with it form a square: these stars are in Pegasus, and are placed at the distance of 15° from each other; they are all of the second magnitude. The two stars forming the western side of the square are called, the upper one Scheat, which is marked β, and which is in the thigh of Pegasus; the under one Markab, which is marked α, and which is in the wing: the lowest star in the eastern side of the square is in the tip of the wing, and is marked γ. The altitude of the Scheat is 55°; azimuth, S. E. ½ E. Altitude of Markab, 43°; azimuth, S. E. by S. ½ E.

A line drawn through γ and β (the diagonal in the square of Pergasus,) and continued to the meridian, will point out Cygnus, a remarkable constellation, in the form of a large cross, in which there is a star of the second magnitude, named Deneb or Arided; it is marked α, and is almost directly upon the meridian, at the altitude of 80°. Cygnus contains six stars of the third magnitude. The constellation Cepheus, which contains no remarkable stars, is situated between Cygnus and the north pole.

Below Pegasus, and nearer the meridian, is Aquarius, containing four stars of the third magnitude. A line drawn from α in Andromeda, through Markab, will point to α in Aquarius. Its altitude is 32°; azimuth, S. S. E.

A bright star of the first magnitude, named Fomalhaut, in Piscis Australis, is then upon the horizon; azimuth, S. S. E.

Delphinus, a small constellation, about 30° below Cygnus, upon the meridian, contains five stars of the third magnitude; four of them are placed close together, and form the figure of a lozenge. A line drawn through the two under stars of the square, will point to it: its altitude is about 50.

A little to the west of Delphinus, but not quite so high, is Aquila, containing one very bright star of the first magnitude, named Atair: it may very easily be known, from having a star on each side of it, of the third magnitude, forming a straight line, the length of the line is only about 5°. Altitude of Atair, 40°; azimuth, S. S. W.

Considerably above Atair, and a little to the west of Cygnus, is Lyra, containing a star of the first magnitude, one of the most brilliant in the firmament. It is called Lyra, or Vega, and is 35° to the north-west of Atair: altitude 60°; azimuth, W. S. W. Lyra, Atair, and Arided form a large triangle.

We come now to notice three constellations, which occupy a large space in the western side of the heavens: these are, Hercules, immediately below Lyra; Serpentarius, between Hercules and the horizon, extending a little more towards the south; and Böotes, reaching from the horizon W. N. W. to the altitude of 45°.

Hercules contains eight stars of the third magnitude: the star in the head, α, named Ras Algethi, is within 5° of α, in the head of Serpentarius. This last is a star of the second magnitude, and is named Ras Alhague: its altitude is 30°; azimuth S. W. by W. ½ W. A line drawn from Lyra, perpendicular to the horizon, will pass between these two stars. The other stars in Hercules extend towards the zenith, and those in Serpentarius towards the horizon.

The constellation Böotes may easily be known from the brilliancy of Arcturus, a star of the first magnitude, and supposed to be the nearest to our system of any in the northern hemisphere: it is within 10° of the horizon; azimuth, W. N. W. Böotes also contains seven stars of the third magnitude, mostly situated higher in the heavens than Arcturus. The star immediately above Arcturus is called the Mezen Mirach, and is marked ε. The star in the left shoulder, δ, named Seginus, forms, with Mirach and Arcturus, a straight line.

Between Serpentarius and Böotes is Serpens, containing one star of the second and eight of the third magnitude; α, in Serpens, is nearly at the same distance from the horizon as Arcturus; azimuth, W.

Above Serpens, and a little to the east of Böotes, is the Northern Crown, containing one star of the second magnitude, named Gemma, and several of the third, which have the appearance of a semicircle. A line, drawn from Lyra to Arcturus, will pass through this constellation.

We come now to Ursa Major, a constellation containing one star of the first, three of the second, and seven of the third magnitude. It may be easily distinguished by those seven stars, which, from their resemblance to a waggon, are called Charles's Wain. The four stars in the form of a long square are the four wheels of the waggon; the three stars in the tail of the Bear, are the three horses, which appear fixed to one of the wheels. The two hind wheels (α named Dubhe and β,) are called the pointers, from their always pointing nearly to the north pole; hence the pole star may be known. The altitude of Dubhe is 30°; azimuth, N. by W. ½ W.: the distance between the two pointers is 5°; the distance between the pole star and Dubhe the upper pointer is 33°.

Ursa Minor, besides the pole star, of the second magnitude, situated in the tail, contains three of the third, and three of the fourth magnitude. These form some resemblance to the figure of Charles's Wain inverted, and may easily be traced.

Draco, containing four stars of the second, and seven of the third magnitude, spreads itself in the heavens near Ursa Minor; the four stars in the head are in the form of a rhombus, or lozenge; the tail is between the pole star and Charles's Wain.

Besides these constellations, there are a number of others, which, as they contain no remarkable stars, we have not described: an enumeration of these will suffice.

The Lynx, between Ursa Major and Auriga; Camelopardalus, between Ursa Major and Cassiopeia; Musca and the Greater or Less Triangles, between Aries and Perseus; Equuleus, close to the head of Pegasus; Sagittarius, setting in the S. W.; Antinöus, and Sobieski's Shield, below Aquila; the Fox and the Goose, between Aquila and Cygnus; the Greyhounds, and Berenice's Hair, between Böotes and Ursa Major: and Leo Minor, below Ursa Major.

As one day brings the stars nearly four minutes earlier into the same situation than they were on the preceding day; by making that allowance, the above view of the heavens will answer for September 6th, about 10 o'clock; September 21st, about nine o'clock; or October 21st, about seven o'clock in the evening.

2. Point out the situation of the stars for the latitude of London, on January 1st, at eight o'clock in the evening.

3. Required the situation of the stars for the latitude of Paris, on March 21st, at nine in the evening.

4. What are the principal constellations that will be above the horizon of Edinburgh, on May 1st, at ten o'clock in the evening.

GLOBULAR CHART, the representation of the surface, or of some part of the surface, of the terrestrial globe upon a plane, wherein the parallels of latitude are circles nearly concentric, the meridian curves bending towards the poles, and the rhomb lines are also the curves.

GLOBULAR *Projection*. *See* MAP.

GLOBULAR *Sailing*. *See* SAILING.

GLOW WORM. *See* LAMPYRIS.

GLUCINA, in Chemistry, an earth so named from its sweetish taste, and which in the powder or in fragments is almost three times as heavy as water. It is infusible in the fire, does not contract like alumina, by great heat, and has no effect on vegetable colours. It is insoluble in water, but combines with acids, making with them soluble salts, distinguished by a slightly astringent taste. It was first discovered in aqua marina.

GLUE, among Artificers, a tenacious viscid matter, which serves as a cement to connect things together. Glues are of different kinds, according to the various uses they are designed for, as the common glue, glove glue, parchment glue, isinglass glue, &c. The common or strong glue, is made of the skins of animals; as oxen, cows, calves, sheep, &c., and the older the creature is, the better is the glue made of its hide. Indeed, whole skins are but rarely used for this purpose, but only the shavings, parings, or scraps of them; or the feet, sinews, &c. In making glue of parings, they first steep them two or three days in water; then washing them well out, they boil them to the consistence of a thick jelly, which they pass, while hot, through osier baskets, to separate the impurities from it, and then let it stand some time to purify it further: when all the filth and ordures are settled to the bottom of the vessel, they melt and boil it a second time. They next pour it into flat frames or moulds, whence it is taken out pretty hard and solid, and cut into square pieces or cakes. They afterwards dry it in the wind, in a sort of coarse net; and at last string it, to finish its drying. The best glue is that which is oldest; and the surest way to try its goodness, is to lay a piece to steep three or four days, and if it swell considerably without melting, and when taken out resume its former dryness, it is excellent. A glue that will hold against fire or water may be made thus: mix a handful of quick lime with four ounces of linseed oil, boil them to a good thickness, then spread it on tin plates in the shade, and it will become exceedingly hard, but may be dissolved over a fire, as glue, and will effect the business to admiration.

GLUE, *Method of Preparing and Using*.—Set a quart of water on the fire, then put in about half a pound of good glue, and boil them gently together till the glue be entirely dissolved, and of a due consistence. When glue is to be used, it must be made thoroughly hot; after which, with a brush dipped in it, besmear the faces of the joints as quick as possible; then clapping them together, slide or rub them lengthwise one upon another two or three times, to settle them close; and so let them stand till they are dry and firm.

GLUE, *Parchment*, is made by boiling gently shreds of parchment in water, in the proportion of one pound of the former to six quarts of the latter, till it be reduced to one quart: the fluid is then strained from the dregs, and afterwards boiled to the consistence of glue. Isinglass glue is made in the same way: but this is improved by dissolving the isinglass in alcohol, by means of a gentle heat. *See* CEMENT.

GLUTEN. With the fecula and saccharine matter which compose the principal part of nutritive grain, is another substance approaching more nearly in its characters to animal matter than any other product of the vegetable system. From the resemblance in its properties to the animal principle formerly called gluten, but now described under the term *fibrin*, it has received the name of vegetable gluten. It is obtained in large quantities from wheat, amounting to the 12th part of the whole grain, by kneading the flour into paste, which is to be washed very cautiously, by kneading it under a jet of water till the water carries off nothing more, but runs off colourless; what remains is gluten: it is ductile and elastic; it has some resemblance to animal tendon or membrane; it is very tenacious, and may be used as a cement for broken porcelain vessels. It has a peculiar smell, with scarcely any taste. When exposed to the air it assumes a brown colour, and becomes apparently covered with a coat of oil. When completely dry it resembles glue, and breaks like glass. It is insoluble in water, alcohol, and ether; but the acids dissolve it, and the alkalies precipitate it. It has a strong affinity for the colouring matter of vegetables, and likewise for resinous substances. When kept moist, it ferments, and emits a very offensive smell; the vapour blackens silver and lead. Its constituent parts are oxygen, hydrogen, carbon, and azote. Though it exists most abundantly in wheat, it is found in large quantities in many other plants. It is gluten that renders wheat so fit for bread.

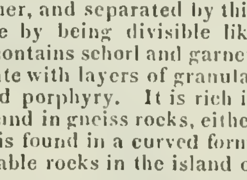
GLYCYRRHIZA, or Liquorice, a genus of the diadelphia-decandria class and order. Natural order of papilionaceæ or leguminosæ. There are four species; tall perennial, herbaceous plants, with the stalks somewhat woody at the bottom. Their propagation is effected by cuttings of the small roots. An open situation and a deep loose soil is the most suitable for them. In three years the roots will be fit to take up. Liquorice is almost the only sweet that quenches thirst, and has been employed in hydropic cases, to prevent the necessity of drinking. An extract is made from the root.

GNAT. *See* Culex.

GNEISS, in Mineralogy, composed of felspar, quartz, and mica, forming plates, laid on each other, and separated by thin layers of mica; differs from granite by being divisible like slate; though, like that, it sometimes contains schorl and garnet. The beds of gneiss sometimes alternate with layers of granular limestone, schistose, hornblende, and porphyry. It is rich in ores; almost every metal has been found in gneiss rocks, either in veins or beds. Sometimes gneiss is found in a curved form, of which there are some very remarkable rocks in the island of Lewis, one of the Hebrides.

GNOMON, in Astronomy, is an instrument or apparatus for measuring the altitudes, declinations, &c. of the sun and stars. The gnomon is usually a pillar, or column, or pyramid, erected upon level ground, or a pavement. For making the more considerable observations, both the ancients and moderns have made great use of it, especially the former; and many have preferred it to the smaller quadrants, both as more accurate, easier made, and more easily applied. The most ancient observation of this kind extant, is that made by Pytheas, in the time of Alexander the Great, at Marseilles, where he found the height of the gnomon was in proportion to the meridian shadow at the summer solstice, as 213⅓ to 600; just the same as Gassendi found it to be, by an observation made at the same place, almost 2000 years after, *viz.* in the year 1636.

The elevation of the pole may be found by means of the gnomon, by finding the meridian height of the sun; for this being given, we have the elevation of the equator, and consequently that of the pole. The meridian height of the sun may be found in the following manner: Let A C, in the annexed figure, represent the gnomon, A B the shadow, C B part of a ray drawn from the centre of the sun passing by the top of the gnomon, and terminating the shadow at B. These lines form the right-angled triangle A B C, and of which the two legs A B, A C may be supposed given, their lengths being accurately found by measurement; then having the two sides, and knowing the angle at A to be a right angle, the angles at B and C are easily found by the known rules of trigonometry: the former of which will give the sun's meridian altitude, and hence the latitude of the place.

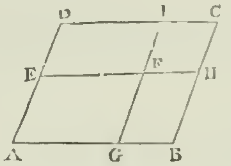


This method of observation, however, is by no means accurate, as is proved by the following deficiencies in the ancient observations made in this manner: 1. The astronomers did not take into account the sun's parallax, which makes his apparent altitude less than it would be if the gnomon were placed at the centre of the earth. 2. They neglected refraction, by which the apparent height of the sun is somewhat increased. 3. They made their calculations as if the shadows were terminated by a ray coming from the sun's centre; whereas it is bounded by one coming from the upper edge of his limb. These errors, however, may be easily allowed for; and when this has been done, the ancient observations are generally found to coincide nearly with those of the moderns.

Gnomon, in Dialling, is the style-pin, or cock of a dial, the shadow of which points out the hours. This is always supposed to represent the axis of the world, to which it is therefore parallel, or coincident, the two ends of it pointing straight to the north and south poles of the world.

Gnomon, in Geometry, is the space included between the lines forming two similar parallelograms, of which the smaller is inscribed within the larger, so as to have one angle in each common to both.

Thus A G F E and A B C D being similar parallelograms, having a common angle at A; then the space G B C F D E is called a gnomon. In the same manner, if G F and E F be produced to H and I, forming another similar parallelogram F H C I, then is also the space F H B A D I a gnomon; and the same may otherwise be formed about the angles D and B.



Gnomonic, or Gnomonical *Projection*, that which represents the circle of a hemisphere upon a plane touching it in the vertex, by lines or rays from the centre of the hemisphere to all the points of the circles to be projected. In this projection all the great circles of the sphere are projected into right lines. Any lesser circle parallel to the plane of projection, is projected into a circle. And any lesser circle not parallel to the plane of projection, is projected into a conic section. The gnomonic projection is also called the *horologiographic projection*, because it is the foundation of dialling. In other respects it is not much used, because the circles of the sphere are projected into conic sections, which are difficult to be described. However, this projection has its conveniences in the solution of some problems of the sphere, on account of the great circles being all projected into right lines. Emerson has given a theory and practice of the gnomonic projection, in his treatise on the "Projection of the Sphere."

Gnomonics, the art of dialling, or of drawing sun and moon, dials, &c. on any given plane, so called, as it shews how to find the hour of the day, &c. by the shadow of the gnomon or style.

GNOSTICS, in Church History, a sect of Christians, so called from their pretensions to be more enlightened than others, and from their affecting to be able to bring mankind to the knowledge of the true God.

GOAT, in Zöology, *Capra*, a genus of quadrupeds, of the order of pecora, of which there are nine species and varieties, *viz.* 1. Capra Ibex, found in several parts of Europe and Asia, dwells in mountainous parts, and is an animal of great strength and agility. The colour is a grayish brown. 2. Capra Ægagrus, or Caucasian Ibex, larger than the common goat, in some degree resembles a stag. The female has neither horns nor beard. It inhabits the highest parts of mount Caucasus, and is strong and swift. 3. Capra Hircus, or common goat, found in almost every part of the globe is various of colour, being black, brown, white, or spotted. The flesh is good when young, and the skin is used for making gloves. The goat goes with young four months and a half. The leather made of the skin of the Chamois goat is highly esteemed. The following are the principal varieties of the common goat: 1. Capra Mambrica, or Syrian goat, is remarkable for its ears, which are long and pendulous. 2. Capra Angorensis, or Angora goat, is generally of a milk-white colour, short-legged, with black, spreading, spirally twisted horns, and the hair on the body hanging in spiral ringlets. From this hair fine camblets are made. 3. Capra Depressa, or African goat, is a very small kind, found in some parts of Africa. 4. Capra Reversa, or Whidah goat, is also a dwarf variety found in Africa, where it is much esteemed as an article of food. 5. Long-horned Whidah goat. 6. Capricorn goat.

GOBIUS, the *Goby*, in Natural History, a genus of fishes of the order thoracici, of which there are twenty-five species.

GOD, the Supreme Being, the first Cause, or Creator of the universe, the upholder and governor of all things, and the only true object of religious worship.

GODFATHERS and GODMOTHERS, persons who at the baptism of infants lay themselves under an indispensable obligation to instruct them in the principles of Christianity, and watch over their conduct.

GOGGLES, in Surgery, instruments used for the cure of squinting, or that distortion of the eyes which occasions this disorder. They are short conical tubes, composed of ivory stained black, with a thin plate of the same ivory fixed in the tubes; through the centre of the plates is a small circular hole, about the size of the pupil of the eye, for the transmission of the rays of light.

GOLD. *See* Aurum.

Gold *Wire*, a cylindrical ingot of silver, superficially gilt, or covered with gold at the fire, and afterwards drawn successively through a great number of little round holes, of a wire-drawing iron, each less than the other, till it is sometimes no bigger than a hair of the head.

Gold *Wire*, flatted, is the former wire flatted between two rollers of polished steel, to fit it to be spun on a stick, or to be used flat, as it is without spinning, in certain stuffs, laces, embroideries, &c.

Gold *Thread*, or *Spun Gold*, is flatted gold wrapped or laid over a thread of silk, by twisting it with a wheel and iron bobbins.

Gold *Beating*. A quantity of pure gold being melted and formed into an ingot, reduced, by forging, into a plate about the thickness of a sheet of paper; the gold-beaters cut the plate into little pieces about an inch square, and lay them in the first or smallest mould to begin to stretch them; after they have been hammered here a while with the smallest hammer, they cut each of them into four, and put them into the second mould, to be extended further. Upon taking them hence, they cut them again into four, and put them into the third mould, out of which they are taken, divided into four as before, and laid in the last or finishing mould, where they are beaten to the degree of thinness required. They take them out of the mould, and dispose them into little paper books, prepared with a little red bole for the gold to stick to; each book ordinarily contains 25 gold leaves.

Gold, *Burnished*, that smoothed or polished with a burnisher.

Gold, *Mosaic*, that applied in pannels on proper ground, distributed into squares, lozenges, and other compartments, part whereof is shadowed, to heighten or raise the rest.

Gold, *Shell*, that used by the illuminers, for writing gold letters. It is made of leaf-gold, reduced into an impalpable powder, by grinding on a marble with honey. After leaving it to infuse some time in aquafortis, they put it in shells, where it sticks. To use it, they dilute it with gum-water, or soap-water.

Gold, *Pure*, that purged by fire of all its impurities, and all alloy. The moderns frequently call it gold of 24 carats. Gold of 22 carats has one part of silver, and another of copper; that of 23 carats has half a part (that is, half a twenty-fourth) of each.

GOLDEN Number, in Chronology, a number shewing what year of the Metonic, or lunar cycle, any given year is. To find the golden number, add 1 to the given year, and divide the sum by 19; what remains will be the golden number; unless 0 remain, for then 19 is the golden number. The discovery of the Metonic cycle exhibited such extensive astronomical knowledge, that it obtained great success and reputation in Greece, insomuch that the order of the period was engraved in letters of gold; whence it acquired the name of *golden number*.

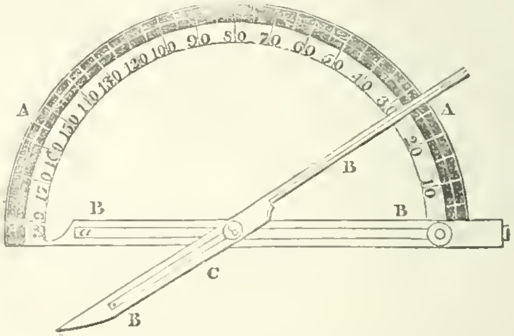
Golden *Rule*, the name usually given by arithmeticians to the Rule of Proportion, or Rule of Three, on account of its extensive usefulness.

GOLDSMITH, or Silversmith, an artist who makes vessels, utensils, and ornaments, in gold and silver. The work is either performed in the mould, or beat out with the hammer, or other engine. All works that have raised figures are cast in a mould, and afterwards polished and finished: plates, or dishes, of silver or gold, are beat out from thin flat plates, and tankards and other vessels of that kind are formed of plates, soldered together, and their mouldings are beat, not cast. The goldsmith is to make his own moulds, and for that reason ought to be a good designer, and have a taste in sculpture: he also ought to know enough of metallurgy to be able to assay mixed metals and to mix the alloy.

GONDOLA, a sort of barge, curiously ornamented, and navigated on the canals of Venice. The middle-sized gondolas are upwards of thirty feet long, and four broad; they always terminate at each end in a very sharp point, which is raised perpendicularly to the full height of a man.

GONG, in Music, a Chinese instrument made of an alloy of twenty parts tin and seventy-eight copper, which is brittle, and malleable when it is tempered, and can accordingly be wrought easily; but it becomes hard, elastic, and brittle, when it is allowed to cool in the open air. It is made in the first of those states, and is afterwards rendered elastic and hard. If struck with a hard body it would break; but if struck with a piece of leather, the sound is at first very small, but by vibration it is communicated to the rest of the mass, and becomes a very loud and terrible noise.

GONIOMETER, an instrument for measuring angles of crystals, &c. The simplest of these is a semicircular scale of degrees A A, and a small pair of nippers B B B B destined to receive the crystal, or other body of which the angle is to be measured. The centre is made moveable, so as to permit the legs B B and B C B to be lengthened or shortened by means of the perforation. The crystal to be measured is applied between the compasses, which being thus set, are applied to the semicircular scale, and the value of the angle may be read off at its edge. Hence in the figure it is set at 30°.



GONIOMETRY, is a method of measuring angles with a pair of compasses, and that without any scale whatever, except a semicircle.

GONIUM, in Natural History, a genus of the vermes infusoria, a worm very simple, flat, angular, and invisible to the naked eye. There are five species, of which G. pectorale is found in pure water; molecules oval, nearly equal in size, set in a quadrangular membrane like diamonds in a ring, the lower ones larger than the rest.

GOOD Behaviour, in Law. Surety for good behaviour, is the bail for any person's good conduct for a certain time; as surety for the peace is a recognizance taken by a competent judge of record for keeping the king's peace. Justices of the peace may also bind persons of evil fame to their good behaviours.

GOOGINGS, certain clamps of iron or other metal, bolted on the stern-post of a ship, whereon to hang the rudder, for which purpose there is a hole in each of them to receive a correspondent spindle, bolted on the back of the rudder, which turns thereby as upon hinges. There are generally four, five, or six googings on a ship's stern-posts and rudder, according to her size, and upon these the rudder is supported, and traverses from side to side as upon an axis. *See* the article Helm.

GOOSEBERRIES. For culinary purposes gooseberries are generally employed before they are ripe; but this is founded on erroneous notions of their chemical properties, since, either for sauces or wine, though they are more cool and refreshing, they do not possess the delicate flavour and rich saccharine qualities which are inherent in the ripe fruit. Wine made of gooseberries has great resemblance to Champaigne. In the making of wine, after the juice has been expressed, it is customary to throw away the *skins* of the fruit. These, however, may with advantage be employed in distillation, as they afford an agreeable spirit somewhat resembling brandy. When kept a few months, this spirit is said to be little inferior, either in strength or flavour, to the best Cogniac brandy. Vinegar may be made from gooseberries. Some of the kinds are bottled while green, and kept for winter use; and others are, for the same purpose, preserved with sugar. Gooseberries vary much in colour, size, and quality. Some are smooth, and others hairy. Some are red, others green, and others yellow or amber-coloured. Wild gooseberries are greatly inferior in size to those which are cultivated in gardens.

GOOSE-Neck, a sort of iron hook fitted on the inner end of a boom, and introduced into a clamp of iron or eye-bolt, which encircles the mast, or is fitted to some other place in the ship, so that it may be unhooked at pleasure.

Goose *Wings of a Sail*, the clues or lower corners of a ship's main-sail or fore-sail, when the middle part is furled or tied up to the yard. The goose wings are only used in a storm, to send before the wind, when the sail, even diminished by a reef, would be too great a press on the ship in that situation.

GORDIUS, *Hair Worm*, a genus of the vermes intestina class and order. There are five species. G. aquaticus is from four to six inches long, of a pale brown colour, and darker at the extremities: it is found in stagnant waters, and twists itself into various contortions and knots; if handled without caution, it will inflict a bite that occasions the whitlow.

GORING, or Goring-Cloth, that part of the skirts of a sail where it gradually widens from the upper part or head, towards the bottom or foot; the goring-cloths are, therefore, those which are cut obliquely and added to the breadth. *See* the article Sail.

GOSSAMER, the name of a fine filmy substance, like cobweb, seen to float in the air in clear days in autumn, is probably formed by the flying spider, which in traversing the air for food, shoots out these threads from its anus, which are borne down by the dew, &c.

GOSSYPIUM, or Cotton, a genus of the polyandria order, in the monadelphia class of plants, and in the natural order of columniferæ. See page 198 for a description of Cotton. In warm countries cotton plants are cultivated in great quantities in the fields, for the sake of the cotton they produce; but the first species is most generally cultivated. The pods are sometimes as large as middling-sized apples, closely filled with the seed surrounding the cotton.

It is impossible to ascertain with precision the actual amount of any of the great manufactures of the kingdom; but of cotton it may be safely asserted, that the value is from thirty to forty millions of pounds sterling per annum. The average annual amount of cotton-wool imported during the last seven years was 145,000,000 lbs., from which deduct 15 millions for exports, and 10 millions for cotton-wool used at home in an unmanufactured state, 120 millions remain. Taking the price of this wool at 1s. per lb., and the increase of value by manufacture at five times the cost of the raw material, the amount will stand thus:—

120,000,000 lb. of cotton at 1s. per lb.	£6,000,000	
Increased value by manufacture......	30,000,000	
Gross amount......		£36,000,000
Average value of cotton manufactures exported..		16,560,379
Home consumption......		£19,439,621

This result is not very dissimilar to the statement made by the president of the Board of Trade in the House of Commons, on the 8th of March, 1824, that the annual value of cotton goods manufactured had risen to the incredible amount of £33,337,000.

Every part of the cotton trade, from the importation of the raw material to its completion by the weaver, the bleacher, the dyer, and the calico printer, is carried on in Lancashire, but the branch for which Manchester is chiefly distinguished is the spinning. In this department of the trade there are at present (August, 1825,) 104 spinning factories in the townships of Manchester, Chorlton-row, Ardwick, Salford, Pendleton, and Hulme, worked by 110 steam-engines, of the aggregate power of 3598 horses. In the year 1787, the number of spinning factories in the county of Lancaster amounted only to 42, and those were in general of a magnitude very inferior to the mills which at present exist in this place.

From a calculation made in 1817, it appears, that the number of persons then employed in the spinning of cotton in this country was 110,768; that the aid they derived from steam was equal to the power of 20,768 horses; and that the number of spindles in motion was 6,615,833. By this immense process 3,987,500,000 hanks of cotton yarn were produced yearly, taking the average at 40 hanks to the pound; and the quantity of coal consumed in their production is stated at 5000 tons.

Raw cotton converted into yarn in the United Kingdom in 1817, ...	110,000,000 lb.	
Loss in spinning estimated at 1½ oz. per pound......................	10,312,500	
Quantity of yarn produced, ..		99,687,500 lb.
Number of hanks, taking the average at 40 per lb.		3,937,500,000 lb.
Number of spindles employed, each spindle being supposed to produce two hanks per day, at 300 working days in the year, ...		6,645,833
Number of persons employed in spinning, supposing each to produce 120 hanks per day, ...		110,763
Horse power employed, equal in number to		20,768

Four ounces and a half of coal estimated to produce one hank of No. 40; and 180 lb. of coal per day, equal to one-horse power.

The increase of manufactures since 1817 has been considerable, certainly not less than 20 per cent. as will appear from the increased average annual quantity of cotton wool imported.

The number of men employed in 1825, in one branch of the cotton manufacture in Great Britain, *viz.* in cotton twist spinning, amounts to 250,000, and these men, aided by the power of water and steam, as first movers to machinery, spin as much thread as could have been spun before the introduction of such machinery by the hands of 24 millions of men; and this calculation respecting the power of machinery is supported by a fact otherwise inexplicable; namely, that cotton wool grown in Hindoostan, is imported into Britain, where it is manufactured, and afterwards returned to Hindoostan, and sold there at prices ruinous to the Indian manufacturer, although his workmen are contented with the slender wages of two-pence a day!

About four-fifths of the whole amount of the cotton trade of the kingdom centres in the county of Lancaster; and it is calculated that the capital employed in Lancashire in this trade alone, in buildings and machinery, amounts to £8,000,000. Steam, it has been already observed, is now applied to a considerable extent in the weaving as well as in the spinning; and we have ascertained, that there are at present (July 1825) in the parish of Manchester alone, upwards of 20,000 steam looms in motion. In Mr. Guest's book on "The Cotton Manufactures," the number of steam or power looms in Great Britain were estimated at 10,000; that estimate was even too low, and the probability is, that there are now in England and Scotland not fewer than 40,000 power looms employed in the weaving of cotton alone, 8000 of which are in Scotland.

GOTHIC Style, in Architecture. The characteristics of this manner of building are pointed arches, greater height than breadth in the proportions, and profuse ornament, chiefly derived from an imitation of the leaves and flowers of plants. *See* Architecture.

GOUGE, an instrument or tool used by divers artificers, being a sort of round hollow chisel for cutting holes, &c. either in wood or stone.

GOUGING, is the name given to a barbarous practice in the southern states of North America, where two men fight, and endeavour with their thumbs to scoop out each other's eyes.

GOVERNMENT, in general, is the polity of a state, or an orderly power constituted for the public good. Civil government was instituted for the preservation and advancement of men's civil interests, and for the better security of their lives, liberties, and properties. The various forms of government may be reduced to one of these heads; either the civil authority is delegated to one or more, or else it is still reserved to the whole body of the people; whence arises the distinction of government into monarchy, aristocracy, and democracy. A mixed government is composed by the combination of the simple forms. The government of this country is a mixed government, being formed by a combination of the three regular species; the monarchy residing in the king, the aristocracy in the house of peers, and the republic being represented by the house of commons, so as to unite the advantages and exclude the inconveniences of the several simple forms. The executive power of the laws being lodged in a single person, they have all the advantages of strength and despatch that are to be found in the most absolute monarchy, and the legislature of the kingdom being intrusted to three distinct powers, entirely independent of each other, and actuated by different springs, and attentive to different interests, there can be no inconvenience attempted by either, but will be understood by one of the other two.

GOVERNOR, a contrivance for equalizing the motion of mills and machinery. When any part of the machinery of a mill is suddenly stopped, or suddenly set going, and the moving power remains the same, an alteration in the velocity of the mill will take place; and it will move faster or slower. Every machine having a certain velocity at which it will work to more advantage than at any other, the change of velocity arising from the foregoing cause, is in all cases a disadvantage, and in delicate operations exceedingly hurtful. In a cotton-mill, for instance, which is calculated to move the spindles at a certain rate, if from any cause the velocity is increased, a loss of work immediately takes place, and an increase of waste from the breaking of threads, &c.; on the other hand, there must be an evident loss from the machinery moving slower than is necessary.

In steam-engines this evil is remedied by a contrivance called a *Governor*, (see the Plate, fig. 1.) Two balls are fixed to the ends of rods, in continual revolution, and as soon as the motion becomes a little too rapid, the balls rise considerably, and, by the intervention of a lever, act upon a *throttle-valve*, which diminishes the quantity of steam admitted, and of course serves to make the motion less rapid.

The Steam-engine Governor.—I K, fig. 1, represents a spindle kept in motion by the engine; A, B, the centrifugal balls; C A, and C B, the rods which suspend the balls. These rods cross one another, and pass through the spindle at C, where the whole are connected by a round pin put through the spindle and the rods at C, which serves as the point of suspension for the centrifugal balls or revolving pendulum. A part of the spindle above C, is square, and nicely polished, so that the piece of brass, M, may slide easily upon it. The piece of brass M is round on the outside, and has an external groove turned upon the upper end of it to receive the lever N O, whose fulcrum is at P. This piece of brass is connected with the ball-rods by two short pieces and joints D E, F G. The construction of steam-engine governors sometimes differs a little from that now described; but if this construction be understood, there will be no difficulty in comprehending any other.

Operation.—When the engine goes too fast, the balls fly off from the spindle, and depress the end, N, of the lever, which partly shuts the throttle-valve, and diminishes the quantity of steam admitted into the cylinder; and, on the other hand, when the engine goes too slow the balls fall down toward the spindle, and elevate the end N of the lever, which partly opens the throttle-valve, and increases the quantity of steam admitted into the cylinder.

Governor for a Wind-mill.—In a wind-mill, when the velocity is increased by the irregular action of the wind, the corn is sometimes forced rapidly through the mill without being sufficiently ground. There is a contrivance for preventing this, (similar to the governor of a steam-engine, but which was much earlier in use,) and called in some parts of England a *lift-tenter.* By means of the centrifugal force of one or more balls, which fly out as soon as the velocity is augmented, and allow a lever to rise with them, the upper mill-stone is made to descend, and bring it a little nearer to the lower one. This machine, says Dr. Gregory, is curious, and might perhaps in other cases be usefully applied. We shall, therefore, describe two constructions on the same principles.

First Construction of Lift-tenters for Wind-mills.—This machine, and part of the stone-spindle and framing with which it is connected, are represented in the Plate, fig. 3. To the stone-spindle there are fixed four arms A, A, A, A; and there are four similar arms B, B, B, B, firmly attached to the hollow cylinder C, which is loose on the spindle F G. The pendulums D, D, D, D, are hung above, to the arms A, A, A, A, and through holes toward their lower extremities pass the arms of the loose cylinder. When the mill is at rest, the pendulums hang vertically; but, by their centrifugal force, when the mill is in motion they hang obliquely; and that obliquity is increased in proportion to the velocity, and proportionately raises the loose cylinder C. This cylinder C acts on the one end of the lever E, which has a connexion with the clove upon which the bridge of the stone-spindle rests, and accordingly raises or depresses the upper mill-stone in proportion as the wind blows weak or strong.

Second Construction.—Another modification of the same principle (applied above the *mill-stones,*) but having one pendulum only, is represented by fig. 4, and will be easily understood from what has been said respecting the first construction of the old lift-tenters.

Water-wheel Governors.—Governors are sometimes applied to water-wheels, and made on various constructions. Smiths' bellows have been applied to that use, the upper board rising or falling in proportion to the velocity of the lower board, which received its motion from the mill. But we shall describe a construction which has for several years been at work in Cartside cotton-mill, erected under the direction of the late Robert Burns, Esq.

First Construction.—The principles of this water-wheel governor are nearly the same as those of the steam-engine governor. It has a revolving pendulum which receives its motion from the mill, and in proportion as the machinery moves faster or slower, the centrifugal force acts upon the governor, and raises or depresses an iron cross, which, acting on a lever, reverses the motion by the wheel-work, which operates upon a sluice so as to enlarge or lessen the passage of the water to the water-wheel; this sluice is made on the principles of the *throttle-valve*, that it may be moved by a small power. So long as the machinery is moving at a proper velocity, this wheel-work of the sluice apparatus remains at rest. Fig. 5, represents different views of this machine, and some of its parts detached. The same letter in all the figures refers to the same part. The revolving pendulum E F G H, receives its motion from the mill-work by means of a rope giving motion to a pulley I. The upright shaft M N, is kept in constant motion by the wheel-work O P R S. The wheel N acts constantly into the two bevelled wheels T and U, and makes them move in contrary directions. They are loose on the shaft when the mill is going at its proper speed. But if the mill moves either too fast or too slow, the one of these wheels, by means of a clutch Q, in a way to be described, is connected with, and carries round, the lying shaft D C, and, by a pair of bevelled wheels, communicates motion to the oblique shaft B W; which again, by a screw X, and quadrant-wheel Y, moves the sluice Z, and, by making it stand more or less oblique, alters the area of the passage for the water.

From inspecting fig. 5, No. 1, it will appear evident that the box *a*, will be raised, or depressed, in proportion as the balls E and F, of the revolving pendulum E F G H, are removed further or brought nearer to the centre of motion; for when the velocity is greatest, the balls E and F, by their centri-

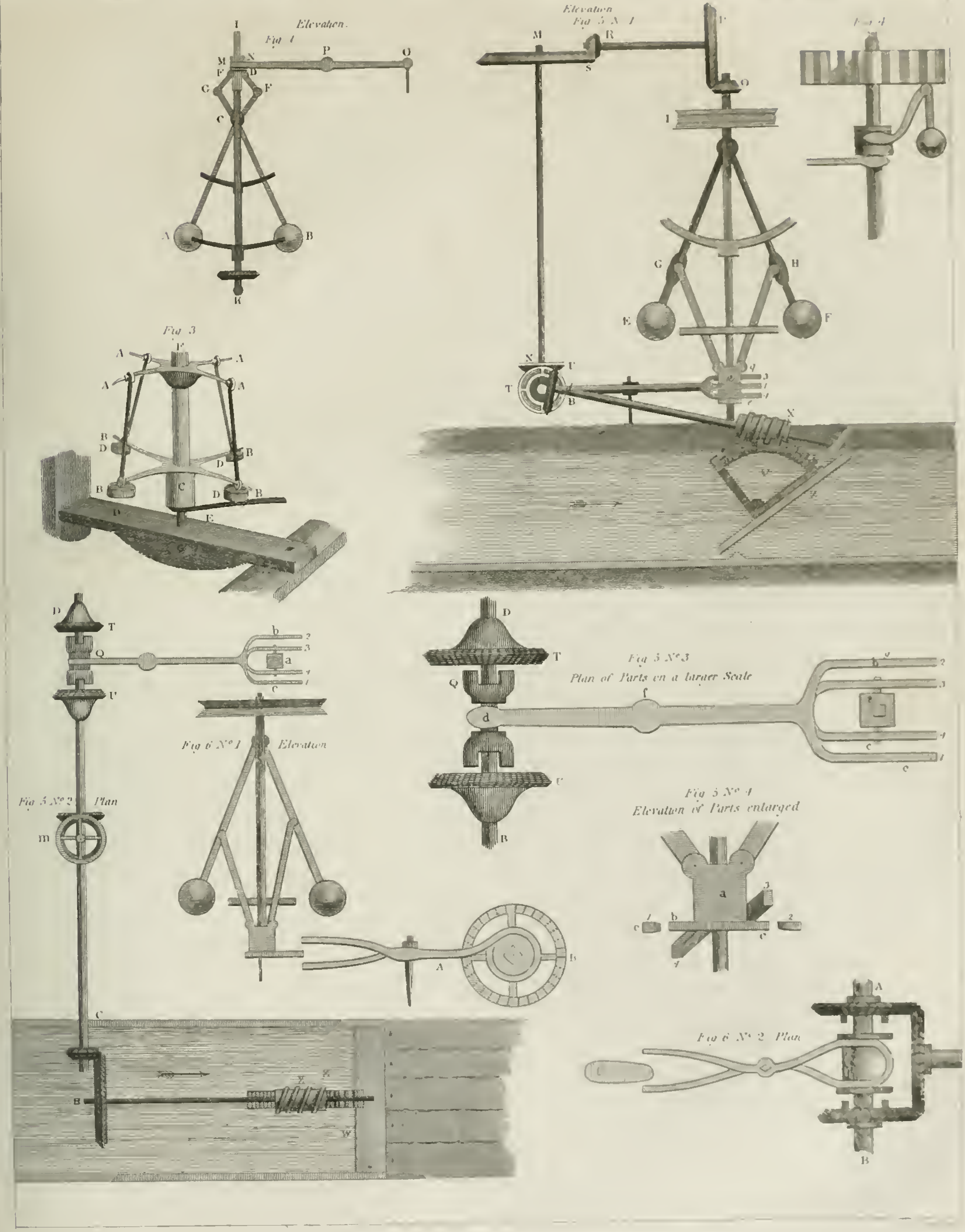


Fig. 1 Elevation.

Fig. 5 No. 1 Elevation

Fig. 4

Fig. 3

Fig. 5 No. 3 Plan of Parts on a larger Scale

Fig. 6 No. 1 Elevation

Fig. 5 No. 2 Plan

Fig. 5 No. 4 Elevation of Parts enlarged

Fig. 6 No. 2 Plan

fugal force, will extend themselves furthest from the centre of motion, and raise the box *a*. See also fig. 5, No. 2, No. 3, and No. 4. To the box *a*, is fixed a cross *b c*. There is a forked lever *d q e*, the fulcrum of which is at *f*, and which turns horizontally. This forked lever has four prongs, 1, 2, 3, 4, represented distinctly in No. 3. When the mill is at its proper speed, the cross works within the prongs 1 and 2; in this situation of the forked lever, the clutch Q is disengaged from both the wheels T and U, and they move on their bushes without carrying round the lying shaft. See No. 2. The clutch is made to slide on a part of the shaft which is square. When the mill moves too quick, the cross gland is raised, and, in turning round, hits the prong 3, which immediately causes the lever to throw the clutch into the arms of the wheel U. This wheel then carries the clutch and shaft round with it, and by the means already described, acts on the sluice, and by lessening the quantity of water falling on the wheel, diminishes its velocity. On the other hand, when the mill goes too slow, the cross is depressed, and, striking the prong 4, reverses the motion of the shaft, and so produces a contrary effect on the sluice. Moreover, the train of wheel-work is so calculated as very much to reduce the motion at the sluice, and this is found from experience to be necessary. Were the area of the aperture too suddenly changed, the effect on the water-wheel would be too violent. Every time the mill is stopped, it is proper to lift the wheel R out of gear. The centre on which the sluice turns should be one-third of its height from the bottom, in order that the pressure of the water above the centre may balance that below. At *m* there is an upright shaft, which is worked by hand when required.

Second Construction of the Water-wheel Governor.—Fig. 6, represents a sluice regulator as executed in some parts of England. It differs little from that already described, only that the lying-shaft A B receives its motion immediately from the mill, instead of from the axle of the revolving pendulum, as in the first construction. From having so minutely described that construction, the attentive reader will find no difficulty in comprehending fig. 6, from inspecting the Plate. See *Buchanan's Essays on Mill Work.*

GRACE, in Music, either in vocal or instrumental performances, consists in giving due place to the decorative additions, and that easy, smooth, and natural expression of the passages which best conveys the beauties of the composition.

GRACE, *Days of*, three days immediately following the time of payment of a bill, within which the creditor must protest if payment is not obtained, in order to entitle him to recover the amount by legal proceedings against the drawer, acceptor, and indorser—one or all.

GRACULA, the *Grakle*, a genus of birds of the order picæ. There are 13 species, of which we shall notice the following: G. kelegiosa, or the minor grakle, is of the size of the blackbird, is found in the East Indies, is rendered familiar with the greatest ease, and taught to speak with greater facility than even the parrot, and also enounces its words with more distinctness. It feeds on berries and fruits, and is particularly partial to cherries. The paradisæa tristis is rather larger than the former, and inhabits the Philippine islands. It is exceedingly voracious, and has been known to swallow a young rat nearly two inches long, after beating it against the wires of its cage to soften it.

GRADUATE, one who has taken a degree in an university.

GRADUATION, in Mathematics, the act of graduating or dividing any thing into degrees or equal parts.

GRAFTING, in Gardening, inserting a scion or shoot of a tree into another, so as to make it yield fruit of the same nature with that of the tree from which the graft was taken. The operation is performed in the following manner: cut off the head of the stock at the proper height, and in a fair part of the bark, making a smooth flat top. The most proper size for stocks is from half an inch to an inch in diameter. Dwarf trees are to be grafted within six inches of the ground, and standards as high as the stock will bear, considering whether they are to be half or full standards. The scions should be healthy and strong, and taken from the outsides of fruitful trees, where the juices of the wood have been properly digested by sun and air; they should be taken from trees just in their prime, or at full bearing, and not before. Let them be cut two or three weeks sooner than wanted. The middle of scions is fittest for the purpose; but do not cut off the tops till they are brought out to graft, for they keep best in length. Take off a little of the lower end of the scion first, and then cut it in length so as to have three or four eyes to appear above the claying. The time for grafting is usually from mid-February to mid-March; but in a forward season sooner, and in a backward one sometimes later.

Cleft-grafting has been the most common method. The stocks for this mode should be strong, about three-quarters of an inch diameter, or more; but it may be used with very young stocks, having scions of like thickness. Cut off the head, so as to have (on the sunny side) a smooth part in the stock, where the scion is to be placed, and cutting a part of the stock off slopewise, opposite to this place, leave the top or the crown of the stock about half an inch wide. Then cleave the stock with a strong knife, or thin sharp chisel, about two inches deep, as near the middle as possible, so as not to divide the pith, and if any roughness appears in the slit, smooth it off with a penknife; but something of the wedge kind must be put into the slit to keep it open to receive the scion, leaving proper room to put it in. Cut the scion on each side to the form of a wedge at bottom, an inch or more long, making that side which is to be placed inwards in the stock, thinner by about one-third. Put the scion in, so that its bark and that of the stock may be level; and, consequently, that the two barks may unite and run into each other; for on this one principle depends the whole art of grafting. The graft must be nicely whipped round with wet bass pulled tight, and the whole clayed over to an inch above, and half an inch below, smoothing it off taper with a trowel or knife dipped in water.

Whip-grafting has the advantage of cleft-grafting in neatness, and not requiring the stocks to be so old by a year or two, as very small ones will do; for the stock is directly covered by the scion, and it takes with certainty if properly performed. Having cut the head of the stock off, and the scion to its proper length, slope the lower end of the scion about an inch and a half, and to a point: then cut the stock to answer it, bark against bark, and tie them together exactly to their place, and clay it.

Grafting in the bark, or *crown-grafting*, is a good way both for ease of operation and certainty of success; but it will hardly suit any other fruit than apples or pears. The head being cut off, make a straight slit down and through the bark from the top, at the place destined for the graft, nearly as long as the slope cut off the scion, which may be one and a half or two inches. Loosen the bark a little at the top of the score, and then with some smooth instrument of dry hard wood, ivory, bone, or silver, rather than iron or steel, open the bark sufficiently to receive the scion. This instrument should be thin, tapered, and rounded towards the point, to suit the shape of the scion's face; one side of it flat, and the other a little convex, the flat side being applied to the wood of the stock; let it be rather narrower than the scion, that it may not loosen the bark too wide. Cut a bit of the bark of the scion smooth off at the bottom, that it may not turn up in pushing down. It will be proper to cut the scion with a small shoulder, to rest upon the stock, score the bark on each side the scion, so that it may fall close to the stock, and to the edges of the scion. Bind and clay. This way of grafting is used most properly with strong stocks; and sometimes is applied to large branches, and even trunks of old trees, to change the sorts or renew the wood.

Side-grafting is done in the bark, much like inoculation, a scion being inserted instead of a bud; but there must be a fluent sap first, *i. e.* the bark must part readily from the wood before this mode of grafting is attempted. The head of the stock is not to be cut off, only thinned a little if it is too large and the side shoots taken away. The bark of the stock, where the insertion of the scion is to be, must be cut through in the form of the letter T, as wide and as long as is sufficient to receive the scion, cut as before, with a slope face of at least an inch long, taking advantage (if it may be) of a part of the stock that is a little gibbous. Let the bark of the stock be neatly raised to receive it, but yet no more than necessary; a little bit of the bark may be sliced off the part that is over the cross cut, to receive the scion the better.

Approach-grafting, or *Inarching*, is performed in April or May. When the stock we would graft, and the tree we would propagate, grow near together, bend the best-situated young branch of the tree or shrub to be propagated, to the stock to be grafted, and having determined on the part at which most conveniently to fix the shoot, cut the bark of that part of the shoot off, with nearly half the wood (not to touch the pith) to the length of about three inches for a strong branch, or less for a weaker. Then cut exactly so much of the bark and branch of the stock off, as will receive the cut part of the branch or shoot, so as to bring bark and bark in contact in every part, and if the contrivance of lipping is used, it will secure them better together. Bind and clay, and tie the work so that the wind may have no power over it.

Budding, or *Inoculation*, is the most considerable mode of propagation. It is performed as soon as good shoots with good eyes of the present year can be had, so that the season may be reckoned from mid-June to mid-August. Peaches and nectarines are propagated on plum-stocks. Plums and cherries may be inoculated on sucker stocks of any kind. Pears, if for standards, should be inoculated on pear-stocks, and on those raised from seed rather than suckers; but if for dwarfs, quince-stocks may be best used, to keep the trees from growing off too fast. Let the scions for inoculation be taken only from the outside branches of healthy and fruitful trees, but the buds must not be cut from the upper part of the scions. Before the buds are prepared, get the stock ready to receive them, by taking off lateral shoots, leaving an uncut single stem. At the part fixed on for the inoculation (which should be smooth, and rather on the north side) cut the bark through to the wood in form thus, T, the cross and the down-slit being of the length necessary to take in the bud, which may be cut with from one to two inches of bark; putting the point of a knife (or some other instrument, rather not of iron or steel) into the top of the down-cut of the stock, raise the bark all the way to the bottom, so that it will just receive the bud easily. There are knives made on purpose for budding, with flat ivory hafts. To procure proper buds, put your knife in (suppose) about three-fourths of an inch above the eye, and with a slope downwards cut the scion half through, then do it at the same distance below the eye, and sloping it upwards cut up the middle of the wood, till the knife meets the upper incisions, so the eye, or bud, will be directly in the middle. Then separate the wood from the bark, which is to be done thus: with your nail, or the point of a knife, loosen the bark at the top, and strip it from the wood; or rather with a swan or large goose quill, made in the form of an apple-scoop, (having a regular smooth edge,) push it down between the bark and wood, pressing it against the wood. Examine the inside of the bark, and if there is a cavity just behind the eye or bud, it is good for nothing. The leaf that grows by the eye is to be cut down to near its footstalk. See that the bark of the stock is loosened a proper length and breadth, and if, when the bud is put in, it should prove a little too long, cut the spare part off; so that the top of the bud being squared, falls in straight with the cross cut of the stock. Thus fixed, bind it moderately tight in its place with wet bass, beginning at the bottom, and passing by the bud, go on to the top, or rather above it. Care must be taken that the bud is not hurt, and it is to be left only just starting out between the bass. If the buds have taken, it will be seen in about three weeks or a month, by their appearing fresh and plump. As often as any shoots appear below the budding, cut them off, and also some of the shoots above, if there are many of them: for it is not proper that an inoculated stock should have a large head. In a month loosen the bandage, by taking it off, and putting it on gently again for another month. In March, cut the head of the stock off with a keen knife, close behind the budding, in a sloping direction.—*Watkins's Cyclopædia*.

GRAIN, the name of a small weight, the 20th part of a scruple in apothecaries' weight, and the 24th of a pennyweight troy. A grain-weight of gold-bullion is worth about two-pence, and that of silver half a farthing.

GRAIN also denotes the component particles of stones and metals, the veins of wood, &c.

GRAIN and SEEDS are composed chiefly of starch or coagulated mucilage, generally combined with gluten, oil, or albuminous matter; in corn with gluten, in peas and beans with albuminous matter, and in rapeseed, hempseed, linseed, and the kernels of most nuts, with oils. Sir H. Davy found in 100 parts of wheat sown in autumn, of starch, 77; of gluten, 19. In 100 parts of wheat sown in spring, of starch, 70; of gluten, 24. In 100 parts of Barbary wheat, of starch, 74; of gluten, 23. In 100 parts of Sicilian wheat, of starch, 75; of gluten, 21.

GRALLÆ, in Ornithology, is an order of birds in the Linnæan system, which includes 20 genera, *viz.* the phænicopterus, platalea, palamedea, mycteria, tantalus, ardea, corrira, recurvirostra, scolopax, tringa, fulica, parra, vaginalis, psophia, cancroma, rallus, scopus, glareola, hæmatopus, and charadrius.

GRAMMAR, is the art of speaking and writing a language correctly; and the purpose of language is to communicate our thoughts.

In English there are ten parts of speech, namely, the noun, the article, the adjective, the pronoun, the verb, the participle, the adverb, the preposition, the conjunction, and the interjection.

A *noun*, or, as it is sometimes called, a substantive, is the name of any person, place, or thing, as *James, London, land, leisure*.

An article is a word prefixed to nouns, to point them out, and to shew how far their signification extends.

The articles are *a, an, the*; *the* is definite; *a* and *an* indefinite: thus, we say *the house*, when we mean any particular house; *a house*, when we refer to one generally.

A noun may be known by taking an article before it, as *a book, an owl, the moon*; or by its making sense of itself, as *virtue, poverty, wealth*.

Nouns are either *proper* or *common*:—*proper* nouns are the the names appropriated to individuals, as *Charles, Paris, Thames*; and *common* nouns denote the species of things, as *a man, a city, a river*; thus *Paris* is a proper noun, being a name appropriated to a particular city; but *city* is a common noun, as understood of any city.

All nouns are of the third person when *spoken of*, and of the second when *spoken to*. Examples. *The men run; trees are green*; here *men* and *trees* are spoken *of*, and are of the third person:—*men and citizens, listen to my words*; in this case *men* and *citizens* are spoken *to*, and are of the second person.

To nouns belong person, gender, number, and case.

Gender is the distinction of nouns with regard to sex; there are three genders, the masculine, feminine, and neuter. The *masculine* gender denotes animals of the male kind, as a *man, a horse, a bull*. The feminine gender indicates animals that are females, as *woman, cow, mare*. But the neuter gender signifies objects neither male nor female, as *pen, paper, book*.

Number. There are two numbers belonging to nouns, the *singular* and the *plural*. The singular is used to express one object; and the plural is used when two or more are to be expressed.

The plural is generally formed, (1.) By adding *s* to the singular, as *river, rivers*. (2.) By adding *es* when the singular ends *ch, s, sh, x,* and *z*, as *church, churches; kiss, kisses; lash, lashes; fox, foxes*. (3.) By changing the terminations of nouns ending in *f* or *fe* into *ves*, as *calf, calves; knife, knives*. (4.) When nouns end in *y*, the plural is formed by changing *y* into *ies*, as *fly, flies*.

There are many exceptions to these general rules, as *ox, oxen; muff, muffs; chief, chiefs; key, keys; goose, geese; foot, feet*, &c.

Some nouns admit of a singular termination only, as *wheat, steel, sloth*: some have the plural termination only, as *bellows, scissars, ashes*; and in some nouns the singular and plural are the same, as *deer, sheep*, &c.

Case is the variation of nouns, serving to express the different relations they bear to each other.

English nouns have three cases, the *nominative*, the *possessive*, and the *objective*.

The *nominative* expresses the name of a thing, on the *subject* of the verb; as *the boy runs*.

The *possessive* denotes property or possession, and is formed by adding *s* to the nominative, with an apostrophe before it, as *Solomon's wisdom*, the *cow's crib*. When the noun ends in *s*, the apostrophe only is added, as the *Stationers' arms*.

The *objective* case denotes the *object* of an active verb, or of a proposition; as, Charles teaches James; Charles and James live in London. Nouns are declined thus:

	Singular.	*Plural.*
Nominative.	Man.	Men.
Possessive.	Man's.	Men's.
Objective.	Man.	Men.

The nominative and objective are spelt alike; but in a sentence the nominative comes before the verb, and the objective after a verb active, or preposition.

Adjectives. An *adjective* is a word added to a substantive, to denote its quality, or property, as *white* paper, *black* ink, *green* grass. Adjectives change their terminations to augment or diminish the quality of the noun; and these changes are called *degrees of comparison.* There are three degrees of comparison, the *positive*, as BRAVE; the *comparative*, as BRAVER; and the *superlative*, as BRAVEST.

The *positive* is changed into the *comparative* by the addition of *r*, or *er*; as *wise, wiser*; *hard, harder*; and into the *superlative* by adding *st* or *est*; as *wise, wisest; hard, hardest.*

The words *more* and *most*, placed before an adjective, have the same effect, as *more* wise, *most* wise.

Monosyllables are, for the most part, compared by *er* and *est*; as *hard, harder, hardest*; and *dissyllables* by *more* and *most*; as *modest, more modest, most modest.*

Some adjectives are compared very irregularly, as

Good,	better,	best.	Many,	more,	most.
Little,	less,	least.	Bad,	worse,	worst.

Some comparatives form the superlative by adding *most*, as *fore, former, foremost*; *up, upper, uppermost*; and some adjectives have only two degrees of comparison, as *under, undermost.*

Pronouns. A *pronoun* is a word used as a substitute for a noun, and there are three sorts of pronouns; the PERSONAL, as *I, thou, he; we, ye, they*: the RELATIVE, as *who, which, what*; and the ADJECTIVE, as *some, other, any, one, all, such.*

The third persons singular of the personal pronouns, *he, she*, and *it*, admit of gender; and pronouns, like nouns, have three cases, the nominative, possessive, and objective. They are mostly different from each other.

		Singular.	Plural.
First person.	*Nom.*	I.	We
	Poss.	Mine.	Ours.
	Obj.	Me.	Us.
Second person.	*Nom.*	Thou.	Ye *or* you.
	Poss.	Thine.	Yours.
	Obj.	Thee.	You.
Third person.	*Nom.*	He, she, it.	They, theirs, them.
	Poss.	His, hers, its.	
	Obj.	Him, her, it.	

In pronouns the *first* person is the *speaker*; the *second* is the person *spoken to*; and the *third* is the person *spoken of.*

Relative pronouns are such as relate to some word or phrase going before, which is called the antecedent; these are, *who, which*, and *that*. *Who* is applied to persons, *which* to animals and inanimate things. *That* is applied both to persons and things.

What is a compound relative, and is equivalent to *that which.* "This is what I wished," that is, "the thing which I wished."

Who, which, what, are called interrogatives, when used in asking questions. The cases of *who* are, Nom. *Who.* Poss. *Whose* Obj. *Whom.*

Adjective pronouns are either possessive, distributive, demonstrative, or indefinite.

The *possessive* are those that relate to possession, or property: these are *my, thy, his, her, our, your, their.*

The *distributive* pronouns are those which denote the persons or things that make up a number, as taken separately and singly. these are *each, every, either.*

The *demonstrative* pronouns are those which point out the subjects to which they belong: as *this* and *that; these* and *those.*

The *indefinite* are those which express their subjects in an indefinite or general manner, as *some, other, any, one, all, such.*

The Verb. A *verb* is a word that expresses *action, passion, suffering*, or a *state of being*, as *I write, I am beaten, I am.* And verbs are either *active, transitives*, as *I dig the ground*, or *neuter*, as *I run*, or auxiliary, as *I am.*

A verb transitive supposes a person or thing that acts, and a person or thing that is affected by the action: thus, *I dig the ground*, there is the person who acts, and the ground acted upon.

The person or thing that acts is called the *agent*, and the person or thing acted upon is called the *object*; as when we say, *Alexander conquered Darius;* Alexander is the agent, and Darius the object.

A verb transitive supposes an agent and an object:—a verb intransitive implies an agent, and has no object, as *I walk*; but it may be followed by a noun of the same signification, as *I run a race.*

To find the agent of a transitive verb, we ask the question, *who*, or *what*, before the verb; as *Who* conquered Darius? answer, Alexander, the agent. To find the object, you ask the question, *Whom* did Alexander conquer? answer, Darius, the object.

The radical form of verbs, or that from which all the modifications of them are derived, is that in which they follow the particle *to*; as *to love, to run.*

The auxiliary, or connecting verbs, are, *am, are, be, become, is, was, were*; and they serve to connect qualities with their subjects, or are used in conjunction with other verbs; as *I am cold; John and James are going to London; God is good.*

The person or thing preceding a connecting verb is called the *subject*, and a quality or thing coming after it is called the *predicate.*

The properties of verbs are *mood, tense, number*, and *person.*

Mood expresses the sense of the verb, and there are four moods, the *indicative, imperative, subjunctive*, and *infinitive.*

The *indicative* merely declares a thing, as *I walk; does he walk?*

The *imperative* expresses a command, &c. as *run into the village; copy this writing.*

The *subjunctive* expresses a thing conditionally, and is preceded by a conjunction: *I will love him, though he reprove me. Were he more kind, he would be more amiable;* that is, *if* he were more kind, &c.

The *infinite* mood is preceded by the preposition *to*, and is not limited by person or number; as *to act, to run, to be loved.*

The *tenses* mark the division of time; they are, (1.) The present, expressing the *time now:* (2.) The perfect, expressing *time past:* (3.) The future, expressing *time to come.*

In *verbs* there are *two numbers*, singular and plural, and *three persons, viz.* first, second, and third, singular and plural, answering to the pronouns, *I, thou, he; we, ye* or *you, they.*

All words whatever, except *I, thou, we, ye* or *you*, are of the third person.

The second person of the present tense, indicative mood, is formed by adding *st* or *est*, to the first person, as love, lov*est*; walk, walk*est*, according as the verb has, or has not, the final *e*. In the plural number there is no change; as *we love; ye* or *you love; they love.*

The third person is formed by adding to the first *th* or *eth*, as love, lov*eth*; walk, walk*eth*; but *th* or *eth* is often changed to *s*, as he loveth or loves; he walketh or walks.

The first and third persons of the perfect tense are formed by adding *d* or *ed*, to the first person of the present, according as the verb has or has not the final *e*; as love, lov*ed*; walk, walk*ed*.

The second person is formed by adding *est* to the first person, which is usually changed into *st*, as *loved, lovedst.* The *future* tense is known by the sign *shall* or *will*; as *I shall* complete this work. *I will* complete it.

The imperative mood has only two persons, the second and third, singular or plural, and *let* is its sign. The *subjunctive* mood has only two tenses, the *present* and *past*, and its signs are *may, can, might, could, would, should.* The infinitive mood has two tenses, the present, as *to write*, and the past, *to have written*, without either number or person.

Participles are certain forms of the verb, and are so called from participating the active *properties* of verbs, and the *form* and *construction* of adjectives. They are the present, and the past or perfect.

The *present* participle is formed by adding *ing* to the verb, as walk, walk*ing*: if the verb end in *e*, the *e* is dropt, as love, lov*ing*; make, mak*ing*; *be* makes *being*, and *dye, dyeing.*

The *perfect* participle is formed by adding *d* or *ed* to the verb, as love, lov*ed*; walk, walk*ed*. But there are many exceptions, as write, written; draw, drawn; bind, bound, &c.

The perfect tense, and perfect participle of verbs, having only one syllable, and ending in *d* or *t*, are the same as the present; as *read*, *read*, having *read*; *hurt*, *hurt*, having *hurt*.

In verbs ending in *d*, preceded by a diphthong, one of the vowels is dropped in the perfect tense and perfect participle; as bleed, bled, having bled; feed, fed, having fed.

In verbs ending in *ing* and *ch*, the perfect tense and perfect participle ends in *ght*; as bring, brought; teach, taught.

Many verbs have the perfect tense and perfect participle ending in *t*; as dwell, dwelt; leave, left; pass, past.

Auxiliary verbs are used with other verbs to ascertain the time and other circumstances of an action with greater precision; and in forming the tenses, the change of termination is confined to the auxiliary, as I *do* love; thou *dost* love; he *doth* love, &c. I *am* loving, thou *art* loving.

An *adverb* is a part of speech joined to a verb, an adjective, and sometimes to another adverb, to express some quality or circumstance respecting it; as he writes *well*, a *truly* benevolent man; he fought *very bravely*.

Some adverbs admit of comparison; as soon, sooner, soonest; and those ending in *ly* are compared by the words *more* and *most*, as godly, more godly, most godly.

Prepositions express the relation that one word has to another; as he went *to* Cambridge. He walked *from* London *to* York *in* four days. They are supported *by* industry.

Conjunctions join words and sentences together, and shew the manner of their dependence upon one another; as John *and* James live in the country. I will run *if* you wish it. Conjunctions are either conjunctive, as *and*, or disjunctive, as *or*.

Interjections are broken or imperfect words, denoting some emotion or passion of the mind; as *alas!* I dread to hear the news. *Oh!* how anxious I am!

Syntax treats of the agreement and connexion of words in a sentence. A *sentence* is an assemblage of words forming a complete sense: the principal parts of which are, the subject, the attribute, and the object. The *subject* is the thing chiefly spoken of; the *attribute* is the thing or action affirmed or denied of it; and the *object* is the thing affected by such action; as, "Alexander pursued Darius;" Alexander is the subject; pursued, the attribute; Darius, the object. The subject is the nominative to the verb, and usually goes before it; and the word or phrase denoting the object follows the verb. "A prudent man restrains his passions:" in this case, "A prudent man," is the subject; "restrains," the attribute; "his passions," the object.

Syntax consists, (1.) Of *concord*, which is the agreement of one word with another, in gender, case, and number. (2.) Of *government*, which is the power which one part of speech has over another in directing its mood, tense, or case.

A verb must agree with its nominative case in number and person; as, "I learn;" "thou walkest;" "the man runs."

Two or more nouns singular, joined together with a conjunction *copulative*, have verbs and pronouns agreeing with them in the plural; as, "Cicero *and I are* well;" but if the conjunction be disjunctive, the verb will be singular, as, "Thomas *or* John *hopes* to be at home."

A noun of multitude may sometimes have a verb or pronoun agreeing with it, either in the singular or plural number, as, "the multitude eagerly *pursue their* pleasures;" or, "the multitude eagerly *pursues its* pleasures."

Pronouns must always agree with their antecedents, and the nouns for which they stand, in gender and number; as, "The man *whom* I respect." "This is the flower *which* I admire." "The boys and girls enjoy *their* play."

When no nominative case comes between the relative and the verb, the relative is the nominative; as, "The friends *who* walked with us."—When a nominative comes between the relative and the verb, the relative is governed by some other verb; as, "*to whom* I owe my being;" here the relative *whom* is governed by the preposition *to*.

Every adjective belongs to a substantive expressed or understood; as, "*Few* are really happy," that is, *few persons*. "*This* is a beautiful plant," that is, *this plant* is, &c.

The article *a* or *an* agrees with the singular nouns only; but the article *the* may agree with singular or plural nouns; as, "the field," "the fields."

One substantive governs another, signifying a different thing in the possessive case; as, "My brother's horse."

Transitive verbs govern the objective case; as, "The master instructs *me* or *him*." "A good cause supports *us* or *them*."

One verb governs another in the infinitive mood; as, "I am ready to *answer* him, or her."

Participles govern the same cases as the verbs from which they are derived; as, "his friend is weary in *admonishing him*."

Adverbs are for the most part placed before adjectives, after transitive or intransitive verbs, and frequently between the auxiliary and the verb; as, "He spoke a *very* long time, and *was attentively heard* by all the company."

Two negatives destroy one another; as, "His manner is *not ungraceful*;" that is, "He has a graceful manner."

Prepositions govern the objective case; as, "He spoke well *of her*." "I ran *by her*, or *him*." "They will come *to us*."

Conjunctions connect the same moods and tenses of verbs, and cases of nouns and pronouns; as, "The friend praised and rewarded us." "The master reproved *him* and *me* and *her*."

Conjunctions that are of a positive nature require the indicative mood; as, "He is healthy *because* he *is* temperate:" but those that imply something doubtful require the subjunctive mood, as, "*If* I were to admonish him, he would not attend."

When the qualities of different things are compared, the latter noun or pronoun agrees with the verb, or is governed by the verb or the preposition expressed or understood; as, "You walk faster than I," that is, "than I walk." "They were more fortunate than we," that is, "than we were." "He loved her more than me," that is, "more than he loved me." "It is better expressed by him than her," that is, "than by her."

GRAMME, the unit in French weights. It is the weight of one-hundredth part of the metre of distilled water, at its maximum density. It answers to 15.444 grains The denominations of weights proceed decimally both ways.

GRANARY, a building to store corn in.

GRANATITE, a stone found in Spain, France, and Switzerland. It is crystallized in a very peculiar form; two six-sided prisms intersect each other, either at right angles or obliquely. It is of a greyish or reddish brown colour. Specific gravity 3.2861. Usually opaque. Glassy or greasy. It is fusible before the blow-pipe. One hundred parts consist of 44 alumina; 33 silica; 13 oxide of iron; 3.84 lime; 1.00 oxide of manganese.

GRAND JURY. The sheriff of every county is bound to return, to every commission of oyer and terminer, and of gaol delivery, and to every session of the peace, twenty-four good and lawful men of the county, some out of every hundred, to inquire, present, do, and execute all those things which on the part of our lord the king shall then and there be commanded them. They ought to be freeholders; but to what amount is not limited by law. Upon their appearance they are sworn upon the Grand Jury, to the amount of twelve at the least, and not more than twenty-three, that twelve may be a majority. They are only to hear evidence on behalf of the prosecution; for the finding of an indictment is only in the nature of an inquiry on accusation, which is afterwards to be tried; and they are only to inquire, upon their oaths, whether there is sufficient cause to call upon the party to answer it. If twelve agree to find the bill, it must be pronounced a true bill, but it cannot be found by a smaller number. The mode of finding a bill is by indorsing it a true bill; when it is rejected it is indorsed "ignoramus," or not found; and no one can be tried by indictment without the finding by a Grand Jury.

GRANITE is considered as the foundation rock on which slate rocks and all secondary rocks are laid. From its great relative depth, granite is not frequently met with, except in situations where it appears to have been forced through the more superficial covering of the globe. Granite is a hard rock, whose constituent parts are the three substances, quartz, felspar, and mica, which are more or less perfectly crystallized, and closely united together. The three minerals of which granite is composed vary much in their proportions in different granite rocks; and often in specimens from the same rock.

The crystals are large, or small, or equally intermixed, in one part, and in another part quartz or felspar greatly predominate. Some granites are composed of small grains, and have large crystals of felspar interspersed; these are denominated porphyritic granites. Specimens of Cornish and Scotch granites are not difficult to procure in London, as they are commonly used for paving-stones. In the former, the felspar is white, in some specimens it is soft and earthy: the mica appears like glistening scales which have a tarnished semi-metallic lustre. The quartz has a vitreous appearance, and is of a light grey colour. In Scotch granite the felspar has more commonly a reddish brown colour. The mica is not unfrequently black and splendent: this distinguishes it at first sight from hornblende, which is sometimes intermixed with this granite. Very small-grained granites can scarcely be distinguished from sand-stone. In general, felspar may be considered as forming the most abundant part of granite; it is sometimes in a decomposing state, owing to the potash which frequently forms a constituent part of this mineral. It is not improbable, however, that what is considered as decomposing granite, may in some instances be the original state of the rock. Granite is not stratified, but is sometimes separated into tabular masses, which have been mistaken for strata. It is more frequently divided into large masses or blocks which have a tendency to assume a rhomboidal form. Granite also exists in round masses, which are composed of concentric spherical layers, separated by granite of a less compact kind, and enclosing a harder central nucleus. These globular masses are three or four yards or more in diameter, and are sometimes found detached, and sometimes imbedded in granite of a softer kind: probably the detached globes of granite were also once imbedded in a similar rock, which has been decomposed and worn away. This globular structure is not peculiar to granite. When granite rises high above the surface, it forms lofty peaks and rugged piles, which at a distance resemble immense ruins.

GRANULATION, the method of dividing metallic substances into grains or small particles, in order to facilitate their combination with other substances, and sometimes for the purpose of readily subdividing them by weight. This is done either by pouring the melted metal into water, or by agitating it in a box until the moment of congelation, at which instant it becomes converted into a powder.

GRANT, in Law, a gift in writing of such a thing as cannot be passed or conveyed by word only, as a grant is the regular method, by the common law, of transferring the property of incorporeal hereditaments, or such things whereof no livery of seisin can be had. The operative words in grants are *dedi et concessi*. "I have given and granted." Grants may be void by uncertainty, impossibility, being against law, a wrong title, or a mode to defraud creditors.

GRAPE. *See* VITIS. Grapes have been repeatedly examined by the best informed chemists and most accurate tests, but without that success which might have been expected. They are found to contain much sugar, a portion of mucilage and jelly, some albumen and colouring matter. Tartrate of potash, tartaric acid; the citric and malic acids have likewise been discovered in them.

GRAPLIN, FIRE, an instrument nearly resembling the following, but differing in the construction of its flukes, which are furnished with strong barbs on its points; these are usually fixed by a chain on the yard-arms of a ship, to grapple any adversary whom she intends to board, and are particularly requisite in fire-ships.

GRAPNEL, or GRAPLING, a sort of small anchor, fitted with four or five flukes or claws, and commonly used to fasten boats or other small vessels.

GRASS, in Botany, one of the seven natural families into which all vegetables are distributed by Linnæus. They are defined to be plants which have very simple leaves, a jointed stem, a husky calyx named a glume, and a single seed. This description includes corn as well as the grasses. Most of these plants are annual or perennial herbs, some of them are erect, others creep upon the ground. The roots in the greatest number creep, and emit fibres from each knot or joint; in others, they are simply branched and fibrous. The stems and branches are round; the leaves are simple, alternate, entire, very long, and commonly narrow; they are generally placed immediately upon the stem, except in the Bamboo, and a few others which have a foot-stalk at the origin of the leaves.

GRATINGS, a sort of open cover for the hatches, resembling lattice-work, serving to give light to the lower apartments, and to permit a circulation of air; both of which are particularly necessary, when, from the turbulence of the sea, the ports between decks are obliged to be shut.

GRAVE, in Music, is applied to a sound which is of a low or deep tone. The thicker the cord or string, the more grave is the note or tone; and the smaller the more acute. *Grave*, in the Italian music, denotes a very grave and slow motion, somewhat faster than adagio, and slower than largo.

GRAVE *Accent*, in Grammar, shews that the voice is to be lowered; its mark stands thus ˋ. *See* ACCENT.

GRAVEL, a congeries of pebbles, which mixed with a stiff loam, makes lasting and elegant walks.

GRAVER. *See* ENGRAVING.

GRAVIMETER, the name given by M. Guyton to an instrument for measuring specific gravities: he adopts this name rather than either areometer or hydrometer, because these latter terms are grounded upon the supposition that the liquid is always the thing weighed; whereas, with regard to solids, the liquid is but the known term of comparison to which the unknown weight is referred. This instrument is executed in glass, and is of a cylindric form, being that which requires the smallest quantity of fluid, and is on that account preferable, except so far as it is necessary to deviate from the security of a vertical position. Like Nicholson's Hydrometer, which is elsewhere explained in this work, it carries two basins; one of them superior, at the extremity of a thin stem, towards the middle of which the fixed point of immersion is marked. The other, or lower basin, terminates in a point; it contains the ballast, and is attached to the cylinder by two branches. The moveable suspension by means of a hook has the inconvenience of shortening the lever which is to secure the vertical position.

The cylinder is 0·71 inches in diameter, and 6·85 inches in length. It carries in the upper basin an additional constant weight of 115 grains. These dimensions might be increased so as to render it capable of receiving a much more considerable weight; but this is unnecessary. In the lower basin used, and consequently entirely immersed in the fluid, is a bulb of glass loaded with a sufficient quantity of mercury, in order that its total weight may be equal to the constant additional weight, added to the weight of the volume of water displaced by this piece. It will be readily understood that the weight being determined at the same temperature at which the instrument was originally adjusted, it will sink to the same mark on the stem, whether it be loaded with a constant additional weight in the upper basin, or whether the effect of this weight be produced by the additional piece in the lower dish. From this explanation there will be no difficulty in seeing how this instrument may be adapted to every case in practice.

It may be used, 1. for solids. It differs not in this respect from Nicholson's hydrometer. The only condition will be, as in his instrument, that the absolute weight of the body to be examined shall be rather less than the constant additional weight, which in this instrument is 115 grains.

2. For liquids of less specific gravity than water, the instrument, without the additional weight above mentioned, weighs about 459 grains, in the dimensions before laid down. It would be easy to limit its weight to the utmost accuracy. We have therefore the range of one-fifth of buoyancy, and consequently the means of ascertaining all the intermediate densities from water to the most highly rectified spirit of wine, which is known to bear in this respect the ratio of 8 to 10 with regard to water.

3. When liquids of greater specific gravity than water are to be tried, the constant weight being applied below, by means of the additional piece, which weighs about 138 grains, the instrument can receive in the upper basin more than 4 times the usual additional weight, without losing the equilibrium of its vertical position. In this state it is capable of shewing the specific gravity of the most concentrated acids.

4. It possesses another property common to Nicholson's in-

strument, namely, that it may be used as a balance to determine the absolute weight of such bodies as do not exceed its additional load.

5. Lastly, the purity of the water being known, it will indicate the degrees of rarefaction and condensation in proportion to its own bulk.

This instrument may be readily constructed by any workman in glass. The additional piece for the lower basin will require some attention to make it agree perfectly with the constant upper weight, as to the immersion of the instrument. But this object may, by careful adjustment, be ascertained with the utmost certainty and accuracy. The bulb of glass is for this purpose drawn out to a fine point, a sufficient quantity of mercury is then introduced to sink it, and the aperture closed with a little piece of wax. The bulb being then placed in the lower basin of the instrument, the upper basin is to be loaded until the mark on the stem becomes accurately coincident with the surface of the water. The sum of the weights added above is precisely equal to that of the quantity of mercury necessary to be added to that in the glass bulb; which done, nothing more is needed than to seal the point by fusion, taking care not to change its bulk. The whole is rendered portable by means of a case in which all the delicate parts are secured from pressure, and the heavier parts supported in such a manner as to resist the excess of motion they are capable of acquiring in consequence of their mass. This last circumstance is frequently overlooked by such workmen as are employed in the package of instruments; whence it necessarily follows, that some strain or fracture must be produced when matters of very unequal density are exposed to receive a common impulse.

Rule to find the specific Gravity of any Solid by the Gravimeter. "From the weight in the upper dish, when the instrument is properly immersed in the unknown fluid, take the weight which is placed with the body in the same scale at the like adjustment. The remainder is the absolute weight of the solid. Multiply this by the specific gravity of the fluid, and reserve the product. From the additional weight when the body is placed in the lower basin, take the weight when it was placed in the upper. The remainder will be the loss of weight by immersion. Divide the reserved product by the loss by immersion, and the quotient will be the specific gravity of the solid with regard to distilled water at the standard temperature and pressure."

To find the specific Gravity of a Fluid proceed thus: "To the weight of the gravimeter add the weight required in the upper basin to sink it in the unknown fluid. Again, to the weight of the gravimeter add the weight required in the same manner to sink it in distilled water. Divide the first sum by the latter, and the quotient will be the specific gravity of the fluid in question."

GRAVING, the act of cleaning a ship's bottom when she is laid aground during the recess of the tide. *See* the article BREAMING.

GRAVITATION, (from *gravitate*, Latin), the act of tending to a centre. Or, gravitation may be more generally defined, the exercise of gravity, or the action which a body exercises on another body by the power of gravity. *See* ATTRACTION.

GRAVITY, (*Gravitas*, Latin,) in Physics, the natural tendency or inclination of bodies towards a centre.

Terrestrial GRAVITY, is that force by which all all bodies are continually urged towards the centre of the earth. It is in consequence of this force that bodies are accelerated in their fall, and when at rest that they press the body, or that part of the body by which they are supported.

As to the cause of gravity, or its nature, nothing whatever is known, and it would be useless and unprofitable to occupy any part of this article in detailing the several vague hypotheses that have been advanced to account for this most important law of nature. All that can be said is, that it appears to be an essential property of matter, or, at least, of all matter that has hitherto become the object of human investigation, though it is by no means certain that matter may not exist which is not subject to its influence.

This part of the subject appears to be totally out of the reach of human comprehension, instead therefore of wasting our time in useless speculation as to the cause, let us only attend to its effects, and content ourselves with examining more particularly the manner in which this principle operates on material bodies, and the laws by which it appears to be regulated; the principal of which, as deduced from experiment, or from the most unequivocal inferences, are as follows:

1. That gravitation takes place between the most minute particles of bodies. 2. That it is proportional to the masses of those bodies. 3. that it varies inversely as the square of the distance in proceeding from the surface of the body upwards, or from its centre. 4. That it varies directly at the distance, in descending from the surface to the centre in uniform spherical bodies. 5. That it acts equally on bodies in a state of rest, as on those in motion, and that its action in the latter case is always the same, whether that motion be to or from the centre of attraction, or in any other direction. 6. That it is transmitted instantaneously from one body to another. With regard to this last, Laplace has shewn, that if the transmission of this force was not instantaneously communicated from the sun to the extreme bounds of the solar system, an acceleration would take place in the motion of the planetary bodies; and as no such acceleration has been observed, beyond what may be accounted for and computed on other principles, we have reason to conclude that the propagation of gravitation is instantaneous.

Gravity, as relating to the science of mechanics, is divided into *absolute* and *relative*.

Absolute GRAVITY, is that by which a body descends freely and perpendicularly in a vacuum or nonresisting medium, the laws of which are given under the article ACCELERATION.

Relative GRAVITY, is that by which a body descends, when the absolute gravity is constantly counteracted by a uniform but inferior force, such as in the descent of bodies down inclined planes, or in resisting mediums. See INCLINED *Plane*, RESISTANCE, and RESISTING *Mediums*.

Specific GRAVITY, is the relative gravity of any body or substance, considered with regard to some other body which is assumed as a standard of comparison, and this standard, by universal consent and practice, is rain water, on account of its being less subject to variation in different circumstances of time, place, &c. than any other body, whether solid or fluid. And by a very fortunate coincidence, at least to English philosophers, it happens, that a cubic foot of rain water weighs 1000 ounces avoirdupois; and consequently assuming this as the specific gravity of rain water, and comparing all other bodies with this, the same numbers that express the specific gravity of bodies, will at the same time denote the weight of a cubic foot of each in avoirdupois ounces, which is a great convenience in numerical computations.

From the preceding definition, we readily draw the following laws of the specific gravity of bodies; *viz.*

1. In bodies of equal magnitude the specific gravities are directly as the weights, or as their densities.
2. In bodies of the same specific gravities the weights will be as the magnitudes.
3. In bodies of equal weights, the specific gravities are inversely as the magnitudes.
4. The weights of different bodies are to each other in the compound ratio of their magnitudes and specific gravities.

Hence it is obvious, that, of the magnitude, weight, and specific gravity of a body, any two of these being given, the third may be found; and we may thus find the magnitude of bodies, which are too irregular, to admit of the application of the common rules of mensuration; or we may by knowing the specific gravity and magnitude, find the weight of bodies which are too ponderous to be submitted to the action of the balance or steel-yard; or, lastly, the magnitude and weight being given, we may ascertain their specific gravities.

Exam. The weight of a marble statue being 748 lbs. avoirdupois, required the number of cubic feet, &c. which it contains; the specific gravity of marble being 2742.

Since a cubic foot weighs 2742 ounces, we have

as 2742 : 748 × 16 : : 1 : 4·36 feet.

2. Required the weight of a block of granite whose length is 63 feet, and breadth and thickness each 12 feet; the specific gravity of granite being 3500.

Here 63 × 12 × 12 = 9072 feet; then again, as 1 : 9072 : : 3500 : 31752000 ounces; or 885 ton, 18¾ cwt. The above are said to be the dimensions of one of the stones in the walls of Balbeck.

Other properties relating to the specific gravity of bodies are as follows; *viz.* 1. A body immersed in a fluid will sink, if its specific gravity be greater than that of the fluid; if it be less, the body will rise to the top, and be only partly immerged; and if the specific gravity of the solid and fluid be equal, it will remain at rest in any part of the fluid in which it may be placed. 2. When a body is heavier than a fluid, it loses as much of its weight when immersed, as is equal to a quantity of the fluid of the same bulk or magnitude. 3. If the specific gravity of the fluid be greater than that of the body, then the quantity of the fluid displaced by the part immerged, is equal to the weight of the whole body. And hence, as the specific gravity of the fluid is to that of the body, so is the whole magnitude of the body to the part immerged. 4. The specific gravities of equal solids, are as their parts immerged in the same fluid. 5. The specific gravities of fluids are as the weights lost by the same immerged solid.

Hence are drawn the following rules for ascertaining the specific gravities of both solids and fluids.—*To find the specific gravity of a body.* This may be done generally by means of the *hydrostatic balance*, which is contrived for the easy and exact determination of the weights of bodies, either in air, or when immersed in water, or other fluid, from the difference of which the specific gravity of both the solid and fluid may be computed.

1. *When the body is heavier than water.* Weigh it both out of water and in water; then say,

As the weight lost in water
Is to the whole or absolute weight,
So is the specific gravity of water
To that of the body.

2. *When the body is lighter than Water.* In this case attach to it a piece of another body heavier than water, so that the mass compounded of the two may sink together. Weigh the denser body and the compound body separately, both out of the water and in it; and find how much each loses in the water by subtracting its weight in water from its weight in air; and subtract the less of these remainders from the greater. Then use this proportion.

As the last remainder
Is to the weight of the light body in air,
So is the specific gravity of water
To the specific gravity of the body.

3. *When the specific gravity of a fluid is required.* Take a piece of some body of known specific gravity; weigh it both in and out of the fluid, and find the loss of weight by taking the difference of these two; then say,

As the whole or absolute weight
Is to the weight,
So is the specific gravity of the solid
To the specific gravity of the fluid.

In the case of solid substances, they may be either denser than water or rarer, and they may be insoluble in it or incapable of solution. The mode of determining their specific gravity will accordingly be different.

1. Insoluble solid bodies, denser than water are weighed *in vacuo*, and then in distilled water: and the loss of weight which they suffer by immersion, is to their whole weight, as unit is to their specific gravity.

2. Insoluble solid bodies, lighter than water, require to be joined to some heavier substance, in order to make them sink in that liquid. The weight of the ballast, when immersed alone, must be previously ascertained. This weight, diminished, by the weight of the compound after immersion, will therefore give the buoyant power, or the weight of a mass of water equal to the bulk of the rare substance. The weight thus corrected is hence to the weight of the substance *in vacuo*, as unit is to its specific gravity. The computation may be simplified, however, by using what is called a *water-weight*, or an exact counterpoise of the tongs or bucket by which the body is kept immersed in the fluid.

3. When the solid substances to be examined are saline, or liable to solution in water, they may be gently heated, and covered with a thin coat of melted bees'-wax. Thus defended, they may now be plunged without any risk in distilled water. A slight allowance should be made for the buoyant influence of the coat of wax itself, which, however, must be very minute, since this plastic material has very nearly the density of water itself.

A solid substance, rarer than the fluid medium, must evidently sink, till it displace an equal weight of the fluid. The submerged part of the solid hence always marks the volume of this equiponderant mass. If the floating body have a globular shape, terminated by a long slender stem, its depression in any liquid will measure the smallest differences of specific gravity. The stem may be made exactly cylindrical, for instance, and divided into portions which correspond to the thousandth parts of the bulk of the ball. Such is the general construction of the *hydrometer*, a very convenient instrument for examining readily the densities of different liquids. The stem will scarcely bear more than an hundred distinct subdivisions; but the range can be easily enlarged, by attaching, as circumstances may require, loads answering to 100, 200, 300, &c.

One of the easiest and simplest methods of determining the densities of different liquids, is by a set of small glass beads, previously adjusted, and numerically marked. Thrown into any liquor, the heavier balls sink, till they approach the required density, and become gradually buoyant, and the one which first rises to the surface indicates, in thousandth parts, the specific gravity of the fluid. These balls are adapted for examining liquids, whether lighter or heavier than water.

But the most accurate and concise mode of ascertaining the density of liquids, is to employ a small glass measure with a very short narrow neck, and adjusted to hold exactly a thousand grains of distilled water. The vessel being filled with any other liquid, the weight of it is observed, and thence its relative density to water may be found, by merely striking off three decimal places. At each operation, the glass must be carefully rinsed with pure water, and again dried, by heating it, and then sucking out the humified air, for a few minutes, by help of a slender inserted tube.

If fluids of various densities, and not disposed to unite in any chemical affinity, be poured into a vessel, they will arrange themselves in horizontal strata, according to their respective densities, the heavier always occupying a lower place. This stratified arrangement of the several fluids will succeed, even though a mutual attraction should subsist, provided only that its operation be feeble and slow. Thus a body of quicksilver may occupy the bottom of a glass vessel, above it a layer of concentrated sulphuric acid, next this a layer of pure water, and then another layer of alcohol. The sulphuric acid would scarcely act at all upon the mercury, and a considerable time would elapse before the water sensibly penetrated the acid, or the alcohol the water. Bodies of different densities might remain suspended in those strata. Thus, while a ball of platinum would lie at the bottom of the quicksilver, an iron ball would float on its surface; but a ball of brick would be lifted up to the acid, and a ball of beech would swim in the water, and another of cork might rest on the top of the alcohol.

Table of Specific Gravities of Metals, Stones, Earths, &c.

It may be convenient here to state, merely in round numbers, the specific gravities of the more remarkable substances.

Metals.	
Platinum, purified, ...	19·50
——— hammered, ..	20·34
——— laminated, ..	20·34
——— drawn into wire,	22·07
Gold pure and cast,....	19·26
—— hammered, ...	19·36
Mercury, ...	13·57
Lead, cast, ...	11·35
Silver, pure and cast,..	10·47
—— hammered, ...	10·51
Bismuth, cast, ...	9·82
Copper, cast, ...	8·79
——— wire, ...	8·89
Brass, cast, ...	8·40
—— wire, ...	8·54
Cobalt and Nickel, cast,	7·81
Iron, cast, ...	7·21
Iron, malleable, ...	7·79
Steel, soft, ...	7·83
—— hammered, ...	7·84
Tin, cast, ...	7·30
Zinc, cast, ...	7·20
Antimony, cast, ...	4·95
Molybdænum, ...	4·74
Sulphate of barytes.....	4·43
Zircon of Ceylon, ...	4·41
Stones.	
Oriental ruby, ...	4·28
Brazilian ruby, ...	3·53
Bohemian garnet, ...	4·19
Oriental topaz, ...	4·01
Diamond, ...	3·50
Crude manganese, ...	3·53
Flint glass, ...	2·89
Glass of St Gobin, ...	2·49
Fluor spar, ...	3·18
Parian marble, ...	2·34

Peruvian emerald,	2·78
Jasper,	2·70
Earths, &c.	
Carbonate of lime,	2·71
Rock crystal,	2·65
Flint,	2·59
Sulphate of lime,	2·32
Sulphate of soda,	2·20
Common salt,	2·13
Native sulphur,	2·03
Nitre,	2·00
Alabaster,	1·87
Phosphorus,	1·77
Plumbago,	1·86
Alum,	1·72
Asphaltum,	1.40
Jet,	1·24
Coal, from	1·24 to 1·30
Sulphuric acid,	1·84
Nitric acid,	1·22
Muriatic acid,	1·19
Liquids, Oils, &c.	
Equal parts by weight of water and alcohol,	·93
Ice,	·92
Strong alcohol,	·82
Sulphuric æther,	·74
Naphtha,	·71
Sea water,	1·03
Oil of sassafras,	1·09
Linseed oil,	·94
Olive oil,	·91
White sugar,	1·61
Resins, Gums, &c.	
Gum arabic and honey,	1·45
Pitch,	1·15
Isinglass,	1·11
Yellow amber,	1·08
Hen's egg, fresh laid,	1·09
Human blood,	1·05
Camphor,	·99
White wax,	·97
Tallow,	·94
Pearl,	2·75
Sheep's bone,	2·22
Ivory,	1·92
Ox's horn,	1·84
Wood.	
Lignum vitæ,	1·33
Ebony,	1·18
Mahogany,	1·06
Dry oak,	·93
Beech,	·85
Ash,	·84
Elm, from	80 to ·60
Fir, from	57 to ·50
Poplar,	·38
Cork,	·24
Gases.	
Chlorine,	·00302
Carbonic acid gas,	·00164
Oxygen gas,	·00134
Atmospheric air,	·00121
Azotic gas,	·00098
Hydrogen gas,	·00008

One hundred cubic inches of chlorine, carbonic acid gas, oxygen gas, atmospheric air, azotic gas, and hydrogen gas, weigh respectively 76·2, 46·5, 33·9, 30·5, 29·6, and 2·1 grains troy. One cubic inch of distilled water at the ordinary temperature of 62 degrees Fahrenheit, weighs in air 252·5 grains. Hence the weight of a cylindrical inch of water weighs 198·3 grains; but the same measure of quicksilver would weigh 2691 grains, which affords a ready method for ascertaining the diameters of very narrow or capillary glass tubes.

Since the avoirdupois pound contains 7001 grains Troy, it must be equal to the weight of 27,727 cubic inches of water. Wherefore, a cubic foot of water weighs 62,322 pounds, or almost exactly one thousand ounces avoirdupois. A cubic foot of water seems to have anciently corresponded to the weight of a bushel or firlot (*fourthlet*) of wheat, four of which make a boll, eight times this a ton, and the double of this again a chalder. The ton is therefore 2000 lbs., or more generally reckoned twenty hundred weight, each hundred consisting of 112 lb.

The weight of a cable of 720 feet, or 120 fathoms length, worked up from strands 180 fathoms long, is found, by multiplying the sqoare of the circumference in inches by 19½ lb. The square of half the diameter will hence nearly express in pounds the weight of a foot of cord. A chaldron of Newcastle coals is reckoned equal to 1½ ton or 3021 lb. the bushel being only the 34th part, or 84 pounds avoirdupois.

When the specific gravity of any substance is known, it is easy to calculate by the foregoing *table of specific gravities*, the weight of any given bulk of that body, as the figures which denote the specific gravity denote also the number of ounces avoirdupois in a solid foot; the figures are now considered whole numbers.

Exam. 1. *Of Lead.* What is the weight of 7 solid feet of lead? Here the tabular number for lead is 11·352, which multiplied by 7 gives 79·464; and this divided by 16, by 28, and 4, gives 44 cwt. 1 qr. 11 lbs. 12 oz. for the quotient or weight of 7 solid feet of lead.

2. *Of Oak.* What is the weight of 48 solid feet of oak? From the table oak is found to contain 925 ounces in a solid foot; therefore 925 × 48 ÷ 16 by 28 and 4 gives 24 cwt. 3 qrs. 3 lbs. for the weight of 48 feet of solid oak.

3. *Of Cork.* What is the weight of 56 solid feet of cork? Here from the table cork weighs 240 ounces every solid foot; therefore 240 × 56 ÷ 16, by 28, and 4, gives 7 cwt. 2 qrs. for the answer.—This subject is treated hereafter under the word HYDROSTATICS, and the article SOLID *Bodies Floating in Fluid.*

GRAVITY, in Music, is the modification of any sound by which it becomes deep or low in respect of some other sound.

GREAT CIRCLE SAILING, the manner of conducting a ship in, or rather pretty near the arch of a great circle, that passes through the zenith of the two places, *viz.* from whence she came, and to which she is bound.

GREEK FIRE, an invention of the middle ages, which for many years was kept a secret by the court of Constantinople, and enabled the Greeks for a time to resist the arms of the Mahometans. It was employed in battles by land and sea, and on one occasion, was the means of destroying a fleet employed in the siege of Constantinople. It continued to burn under water. The composition is now unknown, and has ceased to be an object of interest, from the invention of the more formidable fire of gunpowder. It is thought that it was made of asphalgum, nitre, and sulphur.

GREEK *Church.* In the eighth century there arose a difference between the eastern and western churches, which, in the course of about two centuries and a half, ended in a total separation. The Greek, or Eastern, or, as it is sometimes called, the Russian church, spread itself over the eastern parts of Europe. It bears a considerable resemblance to the church of Rome, but denies the infallibility and supremacy of the Pope: it rejects also the worship of images, and the doctrine of consubstantiation, or the union of the body of Christ with the sacramental elements. The administration of baptism is performed, as in the case of Christ himself, *St. Matth.* iii., or of Philip and the Eunuch, *Acts*, ch. viii., by immersing the whole body. The Greek church has the same division of clergy, and distinction of ranks and offices, with the church of Rome.

GREEN, one of the original colours excited by the rays of light, and which colour depends on the absorption of carbonic acid.

GREEN, *Brunswick*, is made by saturating cold water with muriated ammonia, and adding three times as much copper clipping as ammonia. The moisture is to be evaporated, taking care that no dust be allowed to get to it. The muriate of ammonia is decomposed by the copper, which is itself corroded and converted into a green oxide. It is then to be digested in successive portions of alcohol, as long as any green oxide is taken up; the solutions are now to be added together, and the liquor to be driven off by a moderate heat; the residue is the pigment required.

GREEN *Cloth*, a board or court of justice, held in the counting house of the king's household, composed of the lord steward and officers under him, who sit daily. To this court is committed the charge and oversight of the king's household in matters of justice and government, with a power to correct all offenders, and to maintain the peace of the verge, or jurisdiction of the court royal; which is every way about two hundred yards from the last gate of the palace where his majesty resides. Without a warrant first obtained from this court, none of the king's servants can be arrested for debt.

GREENHOUSE, or conservatory, a house in a garden contrived for sheltering and preserving the most tender and curious exotic plants, which, in our climate, will not bear to be exposed to the open air during the winter season. These are generally large and beautiful structures, equally ornamental and useful.

GREGORIAN CALENDAR, that which shews the new and full moon, with the time of Easter, and the moveable feasts depending thereon, by means of epacts, disposed through the several months of the Gregorian year.

GREGORIAN *Epoch*, the epocha or time whence the Gregorian calendar or computation took place. The year 1826 is the 244th year of that epocha.

GREGORIAN *Year*, the Julian year corrected or modelled in such a manner as that three secular years, which in the Julian account are bissextile, are here common years, and only every fourth secular year is made a bissextile year.

The Julian computation is more than the solar year by eleven minutes, which in one hundred and thirty-one years amounts to a whole day. By this calculation the vernal equinox was anticipated ten days from the time of the general council of Nice, held in the year 325 of the Christian era, to the time of Pope Gregory XIII., who therefore caused ten days to be taken out of October, in 1582, to make the equinox fall on the twenty-first of March, as it did at the time of that council: and to prevent the like variation for the future, he ordered that three days should be abated in every four hundred years, by reducing the leap-year at the close of each century for three successive centuries to common years, and retaining the leap-year at the close of each fourth century only. This is not exactly conformable to the true solar year, because that in four hundred years it gets one hour and twenty minutes.

GRENADE, or GRENADO, is a kind of small bomb or shell, being furnished with a touch-hole and fuse, and is thrown by hand from the tops, &c. whence they are most generally styled *hand-grenades*. *See* the article ENGAGEMENT. Thuanus observes, that the first time grenadoes were used was at the siege of Wacklindonck, a town near Gueldres; and that the inventor was an inhabitant of Venice, who, in making an experiment of the effect thereof, occasioned two-thirds of that city to be burnt, the fire having been kindled by the fall of a grenado. The best way to secure a man's body from the effect of a grenado is to lie flat down on the ground previous to its explosion.

GRENAILLE, a preparation of copper, which the Chinese use as a red colour in some of their finest china. This colour is thus obtained: when copper is in fusion, water is sprinkled over it, and a pellicle or coat forms itself on the surface of the copper, which is taken off with iron pincers, and immediately thrown into a vessel of cold water, where it forms, by precipitation, the red colour named *Grenaille*.

GREYWACKE, a coarse kind of slate, which has been so named by the Germans. It is thus described by Dr. Thompson: "Greywacke is composed of grains of sand, which are of various sizes, and sometimes even approach in magnitude to rolled masses. These are connected together by a basis of clay-slate, (common slate,) and hence this rock derives its grey colour and solidity. These fragments are sometimes quartz, sometimes a kind of indurated clay-slate, and sometimes flinty-slate. The texture of greywacke becomes gradually finer and finer grained, till at last it can no longer be perceived, and a slaty structure succeeds. It then passes into greywacke slate. Greywacke slate is nothing else than a variety of clay-slate.

GRIFFON, in Heraldry, an imaginary animal feigned by the ancients to be half eagle and half lion; by this form they intended to give an idea of strength and swiftness joined together, with an extraordinary vigilance in guarding the things intrusted to its care.

GRINDING, the reducing hard substances to fine powders, either by the mortar, or by way of levigation upon a marble.

GRIPE, a piece of timber faced against the lower piece of the stern from the foremost end of the keel, joining with the knee of the head: its use is to defend the lower part of the stern from injury, but is often made the larger, that the ship may keep a good wind. *See* the article FOREFOOT.

GRIPE *of a Ship*, is the compass or sharpness of her stern under water, chiefly towards the bottom of her stern. The design of shaping her so is to make her gripe the more, or keep a good wind, for which purpose, sometimes a false stern is put upon the true one.

GRIPES, a machine formed by an assemblage of ropes, hooks, and dead-eyes, and used to secure the boats upon the deck of a ship at sea, and prevent them from being shaken by the labouring of the vessel. The hooks, which are fastened at their ends, are fixed in ring bolts in the deck on each side of the boat; whence, passing over her middle and extremities, they are extended by means of the dead eyes, so as to render the boats firm and secure.

GRIPING, the inclination of a ship to run to windward of her course, particularly when she sails with the wind on her beam or quarter: this effect is partly occasioned by the shock of the waves that strike the ship perpetually on the weather quarter, and force the stern to leeward; but principally by the arrangement of the sails, which disposes the ship continually to edge to windward, while in this situation of sailing; in such case they say, she gripes or is griping.

GRIT, a genus of argillaceous earths, with a texture more or less porous, equable and rough to the touch. It neither gives fire with steel nor effervesces with acids. When fresh and breathed on, it exhales an earthy smell. Its specific gravity varies from 2.0 to 2.6. and is used for mill-stones and whet-stones, and sometimes for filtering-stones and building.

GROG, a general name for any spirituous liquor and water mixed together; but is more particularly applied to rum and water cold without sugar.

GROIN, among Builders, is the angular curve made by the intersection of two semi-cylinders or arches; and is either regular or irregular:—*regular*, as when the intersecting arches, whether semicircular or semi-elliptical, are of the same diameters and heights,—and *irregular*, when one of the arches is semicircular, and the other semi-elliptical.

GROMMET, a sort of ring or small wreath formed of a strand of rope laid in three times round; used to fasten the upper edge of a sail to its stay in different places, by means of which the sail is accordingly hoisted or lowered. Instead of grommets, hanks have been lately introduced. *See* the article HANKS.

GROSS, in law books, signifies absolute or independent on another: thus an advowson in gross is one distinct and separate from the manor.

GROSS *Beak*, the English name of a bird called by authors loxia. *See* LOXIA.

GROSS *Weight*, the whole weight of merchandises, with their dust and dross; as also the bag or chest wherein they are contained. An allowance is usually made out of the gross weight for tare and tret. *See* TARE.

GROTTO, a large deep cavern or den in a mountain or rock.

GROTTO *del Cane*, is a little cavern near Pozzuoli, two miles from Naples; the air contained in it is of a mephitical or noxious quality, it is in truth carbonic acid gas. The vapour rises only to a certain height. When a dog or any other creature is forcibly kept below it, or cannot hold its head above it, it presently loses all motion, and falls down in a swoon, the limbs convulsed and trembling, till at last no more signs of life appear than a very weak and almost insensible beating of the heart and arteries, which, if the animal is left a little longer, quickly ceases too, and then the case is irrevocable; but if it is snatched out and laid in the open air, it soon comes to life again, and sooner, if thrown into the adjacent lake. The effects are produced merely by carbonic acid gas, which accumulates at the bottom of the grotto. A human being is perfectly safe, because the gas rises only a short way from the bottom; but if a man were to lie down, he would suffer in the same manner as a dog.

GROTTO, is also used for a small artificial edifice made in a garden, in imitation of a natural grotto. The outsides of these grottos are usually adorned with rustic architecture, and their inside with shell-work, coral, &c. The following is a good cement for grotto-work: Take two parts of white resin, melt it clear, add to it four parts of bees-wax; when melted together, add some flour of the stone you design to cement, two or three parts, or so much as will give the cement the colour of the stone; to this add one part of the flower of sulphur; first incorporate all together over a gentle fire, and afterwards knead it with your hands in warm water. With this fasten the stones, shells, &c. after they are well dried, and warmed before the fire.

GROUND, in Painting, the surface upon which the figures and other objects are represented. *See* PAINTING.

GROUNDING, the act of laying a ship on shore, in order to bream or repair her: it is also applied to running aground accidentally when under sail.

GROUND TACKLE, a general name given to all sorts of ropes and furniture which belong to the anchors, or which are employed in securing a ship in a road or harbour; as cables, anchors, bow-lines, &c.

GROUP, in Painting and Sculpture, is an assemblage of two or more figures of men, beasts, fruits, or the like, which have some apparent relation to each other.

GROUP, in Music, one of the diminutions of long notes, which in working form a sort of group, knot, or bush.

GROUSE, a species of the *Tetrao*.

GROWING, implies the direction of the cable from the ship towards the anchors, as, the cable grows on the starboard-bow, *i. e.* stretches out forwards towards the board or right side.

GRUB, the name of worms produced from the eggs of beetles, which are at length transformed into winged insects of the same species with their parents.

GRUS, the Crane, contains thirteen stars, *viz.* one of the 2d magnitude, two of the 3d, and two of the 4th; and the whole constellation culminates with Cygnus and Aquarius, but no part of it is visible in our latitudes. β, the brilliant in the eastern wing of the Crane, and of the 2d magnitude, has XXI ho. 56mi. 58 sec. right ascension in Time; (*Ann. Var.* 3″.84,) and 47° 48′ 50″ declination south, (*Ann. Var.* — 17″.15.) This star culminates for the 1st of each month in the year, agreeably to the following table, rectified for 1822 in astronomical time.

Month.	Culm.			Month.	Culm.			Month.	Culm.		
	ho.	mi.	sec.		ho.	mi.	sec.		ho.	mi.	sec.
Jan.	3	10	16	May	19	21	31	Sept.	11	15	0
Feb.	0	58	20	June	17	19	4	Oct.	9	27	12
Mar.	23	5	45	July	15	15	9	Nov.	7	31	11
April	21	12	35	Aug.	13	10	44	Dec.	5	27	46

GRYLLO Talpa, the Mole Cricket, a species of gryllus with the anterior feet palmated.

GRYLLUS, in Natural History, the *Locust, Grasshopper*, and *Cricket*, a genus of insects belonging to the order hemiptera, of which there are 61 species. Among the most numerous species is the gryllus migratorius of Linnæus, or common migratory locust. Legions of these animals are from time to time observed in various parts of the world, where the havock they commit is almost incredible: whole provinces are in a manner desolated by them in the space of a few days, and the air is darkened by their numbers; nay, even when dead, they are still terrible; since the putrefaction arising from their inconceivable number is such that it has been regarded as one of the probable causes of pestilence in the eastern regions. One of the largest species of locust yet known is the *gryllus cristatus* of Linnæus, five or six times the size of the gryllus migratorius; and together with some others of the large kind, is made use of in various parts of the world as an article of food. The *gryllus viridissimus* of Linnæus, one of the largest European species, is often seen during the decline of summer in our own country.

GUANO, a substance found on many of the small islands in the South Sea, which are the resort of numerous flocks of birds, particularly of the ardea and phœnicopterus genus. It is dug from beds fifty or sixty feet thick, and used as a valuable manure in Peru, chiefly for Indian corn.

GUARD, in a general sense, signifies the defence or preservation of any thing; the act of observing what passes, in order to prevent surprise; or the care, precaution, and attention, we make use of, to prevent any thing happening contrary to our intention or inclinations.

Guard, in the Military art, is a duty performed by a body of men, to secure an army or place from being surprised by an enemy. In a garrison the guards are relieved every day, and it comes to every soldier's turn once in three days.

Guard, *Advanced*, is a party of either horse or foot, that marches before a more considerable body, to give notice of any approaching danger.

Guard, *Artillery*, is a detachment from the army to secure the artillery.

Guard, *Main*, that from whence all the other guards are detached.

Guard, *Piquet*, a good number of horse and foot, always in readiness in case of an alarm; the horses are all the time saddled, and the riders booted.

Guard *Boat*, a boat appointed to row the rounds among the ships of war in any harbour, to observe that their officers keep a good look-out.

Guard *Ship*, a vessel to superintend the marine affairs in a harbour or river, and to see that the ships which are not commissioned have their proper watch duly kept.

Guard, in *Fencing*, is a posture proper to defend the body from an enemy's sword. There are several guards of the sword, but they may all be reduced to four; to form a perfect idea of which, we must suppose a circle drawn on a wall, and divided into four cardinal parts, *viz.* top and bottom, right and left. When the point of the sword is directed to the bottom of the circle, with the hilt opposite to its top, the body inclining very forward, this is called the prime or first guard. The second guard is when the point is directed to the right or second point of the same circle, with the hilt of the sword turned to the left, and the body proportionably raised. The tierce, or third guard, is when the point of the sword is raised to the uppermost part of the same circle, in which case the body, the arm, and the sword are in their natural position, and in the mean of the extremes of their motion. The quart, or fourth guard, is when the point of the sword is directed to the fourth point of the circle, descending to the right as far as one-fourth of the tierce, with the outward part of the arm and the flat of the sword turned towards the ground, and the body out of the line to the right, and the hilt of the sword towards the line to the left. There is also a quint, or fifth guard, which is only the return of the point of the sword to the right, after traversing the circle to the point of the prime, from whence it had departed, with a different disposition of the body, arm, and sword. The common centre of all these motions ought to be in the shoulder.

Guard-*Irons*, curved bars of irons placed over the ornamental figures of a ship's head or quarter, to defend them from injury.

GUARDIAN, in Law, is one appointed to take care of a person and his affairs, who by legal imbecility and want of understanding, is incapable of acting for his own interest. Guardian by nature, is the father or mother; and by the common law every father has a right of guardianship of the body of his son and heir until he attains to the age of 21 years. This guardianship extends no farther than the custody of the infant's person. The father may disappoint the mother, and other ancestors, of the guardianship by nature, by appointing a testamentary guardian.

Guardian, by the Common Law, or *Guardian in Soccage*, may be thus explained. If a tenant in soccage die, his heir being under 14, the next of blood to the heir, to whom the inheritance cannot descend, shall be guardian of his body and land till 14; the heir after 14 may choose his own guardian, who shall continue till he is 21. The guardians in soccage are to transact all affairs in their own name, and not in the name of the infant.

Guardian *by Statute, or Testamentary Guardian*. By the statute 12 C. II. c. 24. a father may, by deed or will, attested by two witnesses, appoint, dispose of the custody of his child, born or unborn, to any person except a popish recusant convict, either in possession or reversion, till such child attain 21. This guardian supersedes the guardian in soccage, and has all actions which that guardian might have had. Besides which he has the care of the estate, real and personal. A father cannot, under this statute, appoint one to his natural child. The chancellor, however, will upon application appoint the same person guardian.

Guardians by custom are appointed in the city of London, in the county of Kent, and, with respect to copyhold lands, in some manors.

Guardian, in Chivalry, is obsolete, but extended to twenty-one years.

Guardian, by appointment of the lord chancellor. The court of chancery is the only proper court that has jurisdiction in appointing and removing guardians, and in preventing them and others from abusing the persons or estates. The court determines, as to the right of guardianship, who is the next of kin, and who the most proper guardian; as also orders are made on petition or motion for the provision of infants during any dispute therein; as likewise guardians removed or compelled to give security; they and others punished for abuses committed on infants, and effectual care taken to prevent any abuses intended them in their persons or estates. All courts of justice appoint guardians to infants, to see and prosecute their rights in their respective courts when the occasion calls for it. There are also some cases where an infant may elect a guardian, and the court of chancery allows him to do so after 14.

GUARDIAN *of the Spiritualties*, is he to whom the spiritual jurisdiction of any diocese is committed during the vacancy of the see.

GUDGEONS, in Machinery, having all the weight on the shaft to support, ought to be made sufficiently strong for that purpose; while, to avoid unnecessary friction, they should be made as small in diameter as possible, consistently with the requisite strength and durability. Wrought iron being stronger than cast iron in about the ratio of 7 to 5, will bear a greater weight; yet, cast iron being cheaper, and more easily shaped, is more frequently employed for gudgeons.

Rules for the Gudgeons of Water-wheels.—1. The cube root of the weight of a water-wheel *in hundred weights*, is nearly equal to the *diameter in inches*, of a *cast-iron* gudgeon sufficiently strong to support such wheel. 2. For *wooden* water-wheels, multiply the diameter *in feet* by the width also *in feet*, to which add the square of *half the diameter*: the cube root of the sum will be nearly equal to the diameter of the gudgeon *in inches*.

These, of course, must be regarded as approximations: but it has been inferred from several experiments, that gudgeons of the same size, of cast and of wrought iron, are capable, at a medium, of sustaining weights without flexure, in the proportion of 9 to 14. Upon this principle has been computed the following table, to shew the proportionate diameters of cast-iron and wrought-iron gudgeons.

TABLE *of Cast and Wrought Iron Gudgeons.*

	2	3	4
Diameter of cast-iron gudgeons in inches.	Cube of diameter of cast-iron gudgeons, or the cwts. which the gudgeons may sustain.	Cube of diameter of wrought iron gudgeons.	Diameter of wrought iron gudgeons in inches and parts.
1·	1·	·6428571	·863054
1·25	1·953125	1·2555803	1·063340
1·5	3.375	2·1696427	1·259921
1·75	5·359375	3·4453125	1·514825
2·	8·	5·1428571	1·709976
2·25	11·400625	7·3289732	1·912933
2 5	15·625	10·0446428	2·154435
2·75	20·796875	13·3691196	2·351335
3	27·	17·3571428	2·571282
3 25	34·328125	22·0670803	2·802039
3·5	42·875	27·5625	3·018294
3·75	52·734375	33·9006696	3·239612
4·	64·	41·1428571	3·448217
4·2	76·765625	49·3493303	3·659306
4·5	91·125	58·5803571	3·881936
4·7	107·171875	68·896	4·101566
5·	125·	80·357	4·308870
5·25	144·763125	93·023	4·530655
5·5	166·375	106·955	4·747459
5·75	190·109375	122·213	4·959675
6·	216·	138·857	5·180101
6·25	244·140625	156·948	5·394690
6·5	274·625	176 545	5·609376
6·75	307·546875	197·709	5·828476
7·	343·	220·500	6·041377
7·25	381·078125	244·979	6·257324
7·5	421·875	271·205	6·471274
7·75	465·484375	299·240	6·686882
8·	512·	329·143	6·903436
8 25	561·515625	360·975	7·120367
8 5	614·125	394·795	7·337234
8 75	669·921875	430·664	7.553688
9·	729·	468·643	7 769162
9·25	791·453125	508·791	7·984344
9 5	875·375	562·741	8·257263
9 75	926·859375	595·837	8·415541
10·	1000·	642·857	8·631103
10·25	1076·890625	692·287	8·845085
10·5	1157·625	744 187	9·061309
10 75	1242·296875	798 619	9·279308
11·	1331·	855·643	9·493599

Explanation of the Table of Cast-iron and Wrought iron Gudgeons.—Column 1 and 2 are the same as those calculated for cast-iron gudgeons. Column 3 contains numbers in the proportion of 9 to 14 less than those in column 2. Column 4 contains the cube root of column 3, or the diameters of wrought-iron gudgeons, having the same strength as those of cast-iron in column 1.

Use of the Table.—Example. To find the diameter of a wrought-iron gudgeon of the same strength with one of cast-iron of 3 inches diameter. Look on the 1st column for 3, and on the same line in the 4th column will be found 2·571282, that is, a little more than 2½ inches, the diameter required of the wrought-iron gudgeon. The numbers in the 3d column, being the cube of those in the 4th, another use may be made of this part of the table. For, supposing the 4th column to represent cast-iron gudgeons, the 3d column will represent the hundred weights which cast iron gudgeons of those diameters should sustain.

GUIACUM, or GUAIACUM, is a gum resin, extracted from a West Indian tree called the guaiacum officinale. A part is soluble in water, the rest in alcohol. It is used in syphilis, and other complaints; chiefly in rheumatism, dissolved in ammonia.

GUILD, or *Gild*, a fraternity or company. Among the Saxons the law enacted, that every freeman of 14 years of age should find securities to keep the peace, or be committed: upon which the neighbours entered into an association, and became bound for each other, either to produce him who committed any offence, or to make satisfaction to the injured party, in order to which they raised a sum among themselves, which they put into a common stock. These guilds are now companies, with laws and orders made by themselves, by the license of the prince.

GUINEA, a gold coin struck in England. The pound weight troy of gold is cut into 44 parts and a half, and each part makes a guinea, which is therefore equal to $\frac{2}{89}$ lb. or $\frac{24}{89}$ oz. or 5 dwts. $9\frac{39}{89}$ gr.

GUITAR, or GUITARRA, a musical instrument with five double rows of strings, of which those that are bass are in the middle.

GUM, a thick transparent tasteless fluid, that exudes from certain species of trees. It is adhesive, and gradually hardens without losing its transparency. Gum is chiefly obtained from different species of the mimosa, particularly M. Nilotica, a native of Egypt and Arabia, which is known by the name of gum arabic. The specific gravity of gum is about 1.4. It is not changed by exposure to the air, but is deprived of its colour by the action of the sun. By heat it becomes soft, and is speedily reduced to the state of charcoal, which enters largely into its composition. The constituent parts of gum are carbon, hydrogen, and oxygen, with smaller proportions of nitrogen and lime. The oxygen is much less in quantity than the saccharine matter.

Gum readily dissolves in water, and the solution, which is thick and adhesive, is known by the name of mucilage. It is soluble also in the vegetable acids. Sulphuric acid decomposes it, and converts it into water, acetic acid, and charcoal. With the assistance of heat, muriatic acid and nitric acid produce a similar effect. It is insoluble in alcohol and ether. Such are the chief properties of gum arabic.—There are, besides this, other gums, of which the principal is denominated tragacanth, from the astragalus tragacantha, a native of the island of Crete, which is in the form of vermicular masses; it is less transparent and more adhesive than gum arabic. In our gardens and orchards, we find gum exuding from the cherry and plum trees, which differs chiefly from gum arabic in being softer and more soluble. Gum in a state of mucilage exists in the roots and leaves of a number of plants. It is most abundant in bulbous roots, and of these the hyacinth seems to contain the largest quantity. A pound of the bulbs of this root, when dried, yields four ounces of a powder, which, when macerated in water, gives a mucilage that acts well as a mordant for fixing the colours in calico printing. Gum is used in medicine, and is considered as a specific against the strangury occasioned by blisters; it constitutes, under particular forms, a nutritious food, and it is an important article in the manufacture of ink.

GUM *Resins*, are certain substances that have been used in medicine. They are all solid, generally brittle and opaque, have a strong smell, and a pungent and bitter taste. They consist chiefly of gum and resin, the proportions varying with the particular substance. They are procured by wounding the plants which contain them. The principal of the gum resins are, 1. Ammoniac. 2. Asafœtida. 3. Euphorbium. 4. Galbanum. 5. Gamboge. 6. Myrrh. 7. Oppoponax. 8. Sapagenum, supposed to be had from the ferula persica. All the gum resins which have been analyzed have been found to contain ammonia.

GUN, called by the general name of Cannon, (see that article,) and distinguished by the epithet 'great gun' from the small guns, firelocks, muskets, blunderbusses, &c. See the *Plate* of GUNS.

A truly fortified great iron gun ought to measure eleven diameters of the bore at the circumference of the base ring, nine diameters at the trunnions, and seven at the circumference of the muzzle ring.

A truly fortified great brass gun should measure two diameters less at each place of measurement than the iron gun; that is to say, nine diameters of the bore at the circumference of the base ring; seven at the trunnions, and five at the muzzle ring.

In order to discover when a gun quadrates or hangs well in the carriage, it ought to measure in length seven times her own diameter at the vent; the trunnions ought to be placed at the distance of three diameters from the base ring; then there will remain four diameters in distance from the muzzle.

In order to discover whether the carriage is proper, and of due length for the gun, it ought to be five-eighths the length of the gun, and then the eye will easily discover if it be wide enough, and high enough, or too high.

To dispart a gun, in order to take proper aim at the given object, insert a priming wire into the vent, and let it touch the lower part of the metal of the bore; mark the wire close to the vent, take it out, and rest it on the lower metal of the rose at the muzzle, and the distance between the muzzle-ring and marked part of the wire is the height of the dispart.

In order to find the thickness of the metal at the vent, trunnions, and muzzle, take the diameter of the gun at the vent, and lay it down thus | —— |, which will express the diameter; then insert a priming wire into the vent, and let it rest on the lower metal; mark it close to the vent, and, taking it out, lay the mark on the line of the diameter, thus: | —— | —— |. Crook then the end of the wire a little, that it may enter the vent, and, inserting it a second time, turn it round till it catches the upper metal of the bore; then mark it again close to the vent, set off the distance on the same line of the diameter, and mark how far it reaches from the end of the line, thus;

A B A
| —— | —— | —— |

Then will A and A represent the thickness of the metal, and B the bore of the gun; and if the portions A, A of the line are equal to each other, the thickness of the metal is equal, and, of course, the gun centrally bored. Girt then the gun at the trunnions with waxed twine, and if it measures nine diameters of the bore, the gun is so far truly fortified. Observing the same operation at the muzzle, where it is to measure seven diameters, the process is complete.

In order to discover whether a gun is truly bored, take a spare sponge staff, and fix on it a rammer-head, strike a chalk-line on it, from one end to the other, and put it into the gun as far as it will go, keeping the chalk line uppermost, and exactly in the centre; then prick down the vent with a priming wire, and if you find, on taking out the rammer, you have pricked into the chalk-line, you may reasonably conclude the gun is truly bored; but if you miss the chalk line, that it is not.

In order to discover when a gun is honey-combed, take a spring searcher with five prongs and a reliever; muzzle the searcher, and ram it home in the gun; take off the reliever, and keep turning the searcher backwards and forwards; you will easily discover whether it catches; when it does, mark the staff close to the muzzle; then turn the searcher again as before, and whenever it catches again, mark the staff as in the former instance; so that by laying the staff when drawn out on the outside of the gun, you may nearly judge where the honey-combs are.

In order to discover the depth of the honey-combs, take a searcher with one prong and a reliever: arm the end of the prong with wax, then ram it home in the gun: take off the reliever, and turn the searcher till it catches; then will the impression made in the wax shew the shape and depth of the honey-comb.

If the honey-comb on either side or on the lower metal between the breech and the reinforce ring is three-tenths of an inch deep, the gun is to be condemned; if on the upper metal, four-tenths; if on any part without or beyond the reinforce ring, five-tenths are sufficient.

N. B. A most ingenious instrument, invented by the late General Desaguliers, and since brought to the greatest perfection, has totally superseded the use of this contrivance. All guns intended for sea service are now previously examined by proper officers belonging to the ordnance board, who, by means of this instrument, being able to ascertain with the greatest precision the state and defects of any gun, after a very short examination, of course reject all those which, either from natural defect or subsequent injury, appear unfit for his majesty's service.

To discover whether a gun is sound or cracked, strike a smart blow on it with a hammer: if it rings clear, it may be concluded the gun is sound; if it jars, or emits a hoarse sound, it is most probable the gun is cracked. Or the following method may be taken: stop the vent, and take a piece of touchwood; put it into the gun, and stop the muzzle securely; let the touchwood remain in the gun four or five minutes: if the gun is cracked, the touchwood will burn out; if the gun is sound, it will be extinguished.

In fitting a shot to a gun, divide the diameter of the bore into twenty equal parts, and the diameter of the shot ought to be nineteen of those parts.

With respect to the proper proportion of powder, eighteen-pounders and all inferior calibers require half the weight of the shot; for all above, there are certain rules to find the proper proportion by.

In order to secure a gun, if it break loose, cut down the hammocks, trip the gun, and lash it to the ring-bolts of the side till fine weather. To clear it when a bit is broken in it, draw the gun, and sprinkle powder with a ladle from the breech to the muzzle; this done, drive in a tight tompion with a small score in it, and blow the gun off.

If a shot has fetched way in the gun, in order to secure it, damp the powder or split the tompion: then insert a rope sponge of a small size, and drive the wad home.

If in loading the gun the shot sticks by the way, and if, in firing it, it splits, and you cannot draw the gun; in order to free it, the powder must be damped, and while that is soaking some powder must be mealed, and the gun primed, getting as much powder down the touch-hole as possible; then the gun must be fired off.

When a ship is going to sea immediately, the articles which should be ready for action are, the powder filled, the powder-horns and partridge or grape shot between the guns, hammered shot in the buckets, crows and hand-crows, levers at the guns; nets and cheeses of wads fore and aft; the match-tubs in their proper places, the matches ready, the lockers full of shot, the spare tackles and breechings ready, wet swabs at the door of the magazine and heads of the ladders; the boxes of hand-grenades ready for the tops.

The thickness of the metal of a gun at the vent should be one diameter and a quarter of the bore: in an engagement, there should be one man to every five hundred weight of metal.

The pointing of a gun, so as to strike distant objects, depends on two things, *viz.* 1. Tracing on the outside of the piece a visual line parallel to the axis, which is called disparting, and is performed by taking half the difference of the diameters of the muzzle and base-ring and setting it perpendicularly on the muzzle-ring directly over the centre: for then a line which passes from that point in the base-ring, will, when the piece is truly bored, be parallel to its axis. 2. The other operation is the determining the allowance to be made in distant shot for the incurvation of the flight of the bullet; this is greater or less (*cæteris paribus*) according to the different charges of powder made use of.

N. B. The foregoing principles, remarks, &c. are applicable chiefly to marine artillery, or sea batteries; the details to be found under the words CANNON, CANNONADE, &c. will be read to advantage, in conjunction with the foregoing and succeeding articles.

The *Morning* GUN, a gun fired by an admiral or commodore at day-break every morning.

The *Evening* GUN, one fired by the above at nine o'clock in summer and eight o'clock in winter, every night.

GUN *Boat*, a boat fitted to carry one or more cannon in the bow, so as to cannonade an enemy while she is advancing towards him: they are principally useful in fine weather, smooth water, and shallow ground, to cover the landing of troops, or on such occasions.

GUNNER *of a Ship of War*, an officer appointed to take charge of the ammunition and artillery aboard, to keep the latter properly fitted and in order, and to teach the sailors the exercise of the cannon.

GUNNER'S *Mate*, a petty officer appointed to assist the gunner.

Percussion GUN. *See* PERCUSSION. It has been proposed to ignite great guns and hand-grenades by means of percussion caps, and there can be no doubt of the practicability of this design; but as we have not yet received any certified accounts of actual experiment on this application of the principle of percussion, we shall do no more than touch upon the subject, till we come to the word PERCUSSION.

Quarter GUNNERS, men placed under the direction of the gunner to perform any work relating to the cannon, &c. which he may command; their number is always proportioned to the number of the ship's artillery, one quarter-gunner being allowed to every four guns.

GUN *Room*, an apartment on the after end of the lower gundeck, of large ships of war, partly occupied by the gunner, but in frigates and smaller vessels, where it is below, it is used by the lieutenants as a mess room.

GUN *Shot*, implies the distance of the point-blank range of a cannon-shot; a ship is therefore said to be within gun-shot when she is within that distance.

GUN *Tackles*, are pulleys affixed to each side of the carriage; their use is to run the gun out of the port, or to secure it when at sea.

GUNNERY, the art of charging, directing, and exploding all kinds of fire-arms, though the term is more commonly restricted to the larger pieces of ordnance, as cannons, mortars, &c.

To this art belongs the knowledge of the force and effect of gunpowder, the dimension of the pieces, and the proportions of the powder and ball they carry, with the methods of adjusting, pointing, spunging, &c. Gunnery may be therefore divided into theoretical and practical, which equally belong to a work of this description. Theoretical gunnery consists in computing the angles of elevation, the impetus of projection, the range of the ball, &c. from certain data previously established; we may also consider those experiments which have been made with a view to ascertain the velocity of projection with given charges, the resistance of the air, the deflection of the ball or of the gun, &c. as forming a part of theoretical gunnery. But the best introduction we can offer to the practical rules of gunnery, will be a general view of the *Parabolic Theory* of the motion of projectiles *in vacuo*; that is, of the mathematical principles by which the several circumstances relative to their motion might be determined, if their progress was not impeded or disturbed by the air.

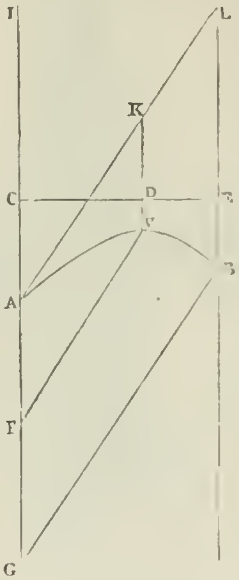
Parabolic Theory of Gunnery.—The motion of a falling body is uniformly accelerated, and that of a body thrown straight upward is uniformly retarded. A falling body acquires an increase of $32\frac{1}{6}$ feet *per* second in every second of its fall, and an ascending body has its velocity lessened as much during every second of its rise.

The space described during any portion of time by a motion uniformly accelerated from rest, is one half of the space uniformly described in the same time with the final velocity of the accelerated motion; and the spaces described from the beginning of the motion are as the squares of the times.

When a body is projected in any direction not perpendicular to the horizon, it will describe a parabola, of which the axis is perpendicular to the horizon.

Let the body be projected from the point A (fig. 1,) in the direction A L, with the velocity which a heavy body would acquire by falling freely through the space C A; the body, by the continual action of gravity, will be continually deflected from the line A L, and will describe the parabolic curve A V B, of which the vertical line C A F is a diameter, A the vertex of this diameter, and A L a tangent at A.

Fig. 1.



Through V, B, any two points of the curve, draw V K, B L, parallel to C A, meeting A L in K and L; and draw V F, B G, parallel to A L, meeting C A produced in F and G. Then let K V, L B, be the spaces through which the body would descend by its gravity in the same times in which it would uniformly pass over the corresponding spaces A K, A L, by the projectile motion; it is plain, from the composition of motions, that the body would arrive at the points V, B, of the curve in the same time that it would have uniformly described A K, A L, with the velocity of the projection, or that it would have fallen through A F, A G. But because the motion along A L is uniform, A K is to A L, as the time of describing A K to the time of describing A L. And because the motion through A G is uniformly accelerated, A F is to A G as the square of the time of describing A F to the square of the time of describing A G; that is, as AK^2 to AL^2, or as VF^2 to BG^2. Consequently the curve is such that the abscisses A F, A G, are as the squares of the corresponding ordinates V F, B G; that is, the curve is a parabola, and A L, parallel to the ordinates, is a tangent at the point A.

If a body be projected from any point A (fig. 1,) in any direction A L, with the velocity acquired by falling from C; the horizontal line C E, drawn through the point C, is the *directrix* of the parabola described by the body.

Take $AF = CA$, then the time of falling through A F is equal to the time of falling through C A; but A K is described with the velocity acquired by falling through C A, and therefore $AK = 2CA$, and $VF = 2AF$; consequently $VF^2 = 4AF^2 = 4AF \times AF = 4CA \times AF$; but in a parabola, the square of any ordinate, as V F, is equal to the rectangle of the corresponding absciss A F, and the parameter of that diameter; therefore 4 C A is the parameter of the diameter A G, and since C A is $\frac{1}{4}$ of the parameter, C E is therefore the directrix of the parabola described by the body projected from A, with the velocity acquired by falling from C.

Hence, since this is true for any other point of the curve, the velocity of the projectile in any point of its path is the same that it would have acquired by falling freely from the height of the directrix to that point.

The times of describing the different arcs A V, A V B, are evidently as the parts A K, A L, of the tangent, or as the corresponding parts C D, C E, of the directrix; therefore the motion estimated horizontally is uniform.

We shall now briefly apply these principles to the construction and solution of the leading problems in gunnery.

The velocity produced by the explosion of a quantity of gunpowder, is, in the preceding theory, conceived to be produced by a fall from a certain height, by the proportion of which its quantity can be accurately determined.

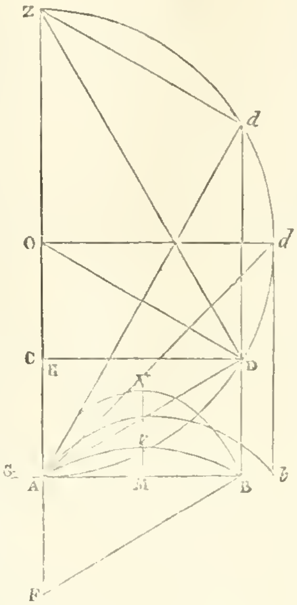
The height C A, (fig. 2,) for producing the velocity of projection, is called the *Impetus.*

The distance A B. between the piece of ordnance and the object, is called the *Amplitude* or *Range.*

The angle contained between the direction of the mortar and the horizontal plane, is called the angle of *Elevation*

Problem 1.—A shell is proposed to be thrown from the point A, with the velocity acquired by falling through C A, in order to hit the object B; the direction A D of the projection is required. (Fig. 2.)

Fig. 2.



Take A Z = 4 C A, and on A Z describe an arc of a circle containing an angle equal to D B A (Euclid, iii. 33); draw the vertical line B D *d*, cutting the circle in D and *d*, and join Z D, Z *d*, and A D, A *d*; then either A D or A *d* is the direction required. For, produce C A downward, and draw B F parallel to A D, because A B touches the circle in A, and A Z cuts it, the angle A D Z is equal to the angle Z A G = D B A, and the alternate angles Z A D. A D B are equal; the triangles Z A D, A D B, are therefore equal, whence B D : D A : : D A : A Z, consequently $DA^2 = BD \times AZ$ or $BF^2 = AF \times AZ = AE \times 4AC$. Therefore a parabola, of which A F is a diameter, and A Z its parameter, will pass through B, and consequently a shell projected from A, in the direction A D, with the velocity acquired by falling through C A, will describe the parabola A *v* B, and hit theobject B.

By similar reasoning, it may be shewn, that the shell, if projected with the same velocity, in the direction A *d*, will describe the parabola A V B, and therefore also hit the object B.

Cor. 1. When the vertical line through B *cuts* the circle, it always cuts it in two points D and *d*, either of which will answer the conditions of the problem.

Cor. 2. When the vertical line through *b* only *touches* the circle, there is but one direction A *d'*, in which the body can be projected to hit the object *b*; this direction evidently bisects the angle Z A B, and from it the directions A D, A *d*, are equidistant; also A *b* is the greatest range.

Problem 2.—A shell is proposed to be projected from the point A, in the direction A D, with the velocity acquired by falling through C A; the distance to which it will reach on the line A B is required. (Fig. 2.)

Take A Z = 4 C A, and describe the arc Z D A cutting A D in D; through D draw the line B D parallel to A Z. cutting A B in B. Then B is the point to which the shell will reach. The proof is evident from problem 1.

Problem 3.—A shell is proposed to be projected from the point A, in the direction A D, in order to hit the object B; the velocity with which it must be projected is required. (Fig. 2.)

Draw the vertical line B D, meeting the direction in D; draw A Z parallel to B D, and equal to $AD^2 \div DB$, and take $CA = \frac{1}{4} AZ$; then C A is the fall which will generate the velocity required. The proof of this is also evident.

From these constructions, numerical solutions are easily deduced. Thus,

Theorem I. *When the line* A B *is horizontal.*

1. The arc Z D A is a semicircle, and the greatest horizontal range A *b* is = O A, the radius of the circle, = 2 C A; and the direction A *d'* is = 45°.

2. The ranges with different directions are proportional to the sines of twice the angles of elevation. For draw D C, *d'*O, perpendicularly to Z A, and join O D; then O *d'* = A *b*, and C D = A B. But *d'*O is the sine of the angle A O *d'*, which is = 2 the ∠ *d'*A B, and C D is the ∠ A O D, which is = 2 the ∠ A Z D = 2 the ∠ D A B; and this is true of all other elevations.

3. When the direction is the same, the ranges with different velocities are proportional to the squares of the velocities. For the figures being similar, the ranges are as thefalls, and the falls as the squares of the velocities acquired by falling.

4. The height to which the projectile riess above the horizontal plane is as the square of the sine of elevation. For *v* M is $= \frac{1}{4}$ D B, and C A is $= \frac{1}{4}$ Z A, and Z A : D B (= H A) : : $ZA^2 : AD^2 :: \text{rad}^2 : \sin^2 AZD$ (= D A B); therefore C A : $vM :: \text{rad}^2 : \sin^2$ elevation; and $vM : VM :: \sin^2 DAB : \sin^2 dAB$.

5. The times of the flights are as the sines of the elevation. For the velocities in the directions A D, A *d*, being the same, the times of describing A D, A *d*, uniformly, (which are the same as the times of describing the parabolas A *v* B, A V B,) will be as A D, A *d*, that is, as the sines of the angles A Z D, A Z *d*, which are equal to the angles D A B, *d* A B.

Again, the time of the flight is the same as that of falling through D B; if then D B be computed in feet, the time will evidently be $= \sqrt{(DB \div 16)}$ nearly, $= \frac{1}{4}\sqrt{DB} = \frac{1}{4}\sqrt{(r \times \tan E)}$; when *r* denotes the range, and E the elevation. When E = 45°, then $d'b = bA = r$; whence the time is $= \frac{1}{4}\sqrt{r}$.

Theorom II. *When the line* A B *is not horizontal.*

Since the angles D B A. A D Z, are equal, it is evident, that when the object B is on an inclined plane, the arc Z D A is less or greater than a semicircle, according as the plane is ascending or descending. It is also plain, that A B : B D : : S,Z A D (= A D B) : S,D A B, and B D : D A : : S,D A B : S,A B D; also, D A : A Z : : S,A D Z (= A B D); therefore A B : A Z : : S,Z A D × S,A Z D : $\sin^2$ A B D, whence A B = (A Z × S,Z A D × S,A Z D) ÷ $\sin^2$ A B D. Now, if we put a = the inclination of the plane, d = the elevation of the mortar above the plane, e = the elevation above the horizon, r = A B the range, and f = C A the impetus, then, by substitution, the above theorem will become $r = 4f \times \text{cosin}\, e \times \sin d \times \sec^2 a$; whence $f = \frac{1}{4} r \times \sec e \times \text{cosec}\, d \times \text{cosin}^2 a$; also, the time of the flight will be $= \sec a. \sin d. 2\sqrt{(f \div 16\frac{1}{2})} = \sec a. \sin. d. \frac{1}{2}\sqrt{f}$, nearly.

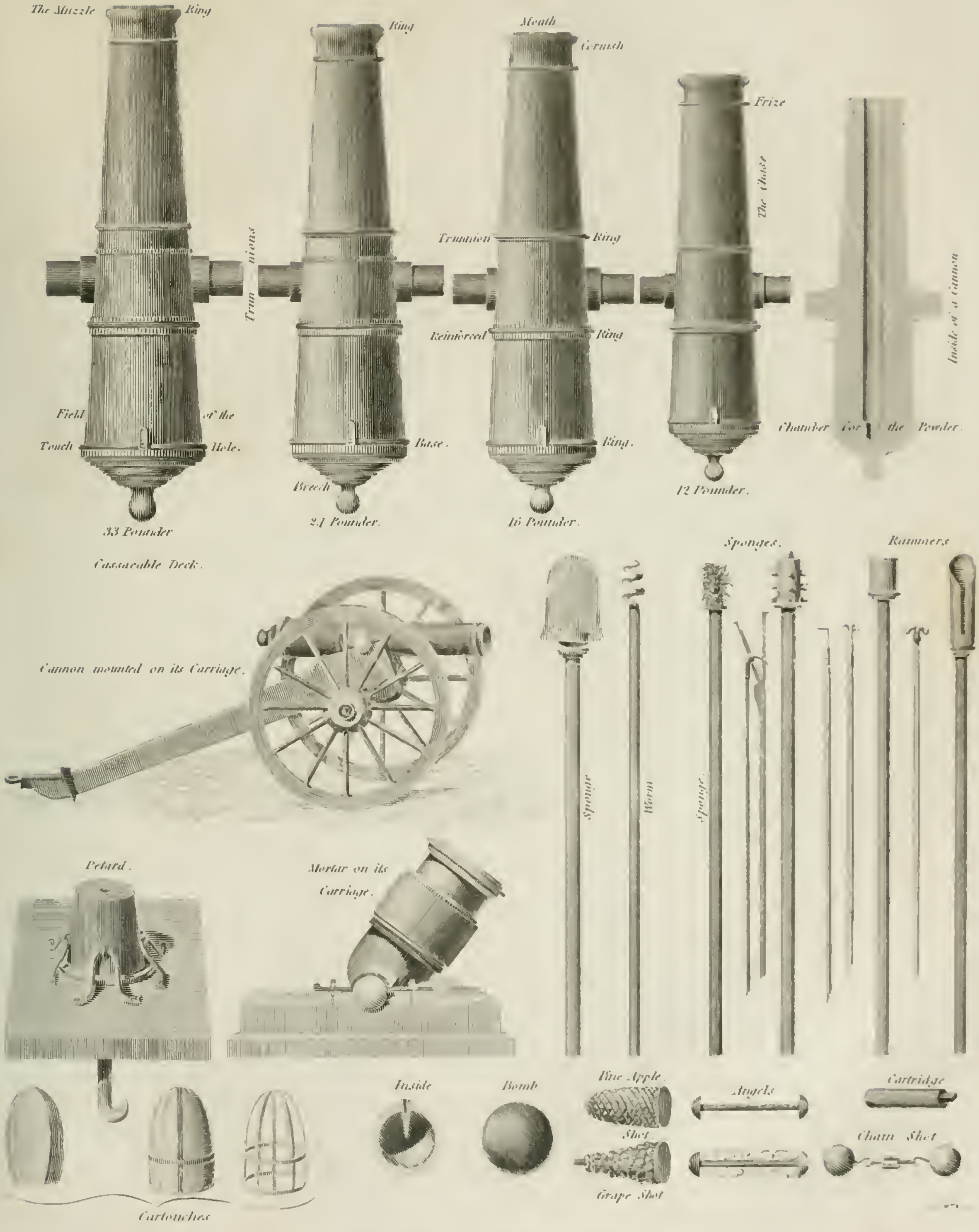
The reader will observe, that in the preceding reasonings, no notice has been taken of the effects of the resistance of the air on the motion of projectiles. Now, as this is very considerable, especially when they are discharged with great velocity, the theory requires to be modelled and corrected by experimental investigations, before it can be applied in practice. There are indeed some cases, such as in the throwing of shells, when the velocity does not exceed 400 feet per second, in which the results by the theory do not differ much from the truth. But when the velocity is great, the resistance of the air occasions a diminution of motion so prodigious, as to render the theory, without the aid of data derived from experiment, of very little use. Thus, a musket-ball, discharged with the ordinary allotment of powder, issues from the piece with the velocity of 1670 feet per second. At the elevation of 45°, it should therefore range 16 miles, whereas it does not range above half a mile. Thus also, a 24 lb. ball, discharged with 16 lbs. of powder, which should range about 16 miles, does not range 3 miles.

Again, the path of a projectile, when the velocity is great, is not parabolical, but is much less incurvated in the ascending than in the descending branch: the greatest range therefore is not made with an elevation of 45° as *in vacuo*, but with an elevation lower, as the first velocity is greater. Thus it is found, that although the larger shells with small velocities range farthest when projected at an elevation of about 45°, yet the smaller shells with great velocities range farthest at an elevation not much above 30°.

These instances sufficiently shew, that such rules as are deduced from theory alone, without the aid of experiment, are unfit for directing practice.

Practical Gunnery.—Of Projections made on the Horizontal Plane.—Prob. 1. To find the velocity of any shot or shell.—*Rule.* Divide double of the weight of the charge of powder by

GUNNERY.


The Muzzle
Ring
Trunnions
Field of the
Touch Hole.
33 Pounder
Cassacable Deck.
Ring
Base.
Breech
24 Pounder.
Mouth
Cornish
Trunnion
Ring
Reinforced
Ring
Ring.
16 Pounder.
Frize
The Chase
12 Pounder.
Inside of a Cannon
Chamber for the Powder.
Cannon mounted on its Carriage.
Sponges.
Rammers.
Sponge
Worm
Sponge.
Petard.
Mortar on its Carriage.
Inside
Bomb
Pine Apple.
Shot.
Grape Shot
Angels
Cartridge
Chain Shot
Cartouches

the weight of the shot, both in lbs. Then if the square root of the quotient be multiplied by 1600, the product will be the velocity, or the number of feet the shot passes over in a second.

Or say, As the square root of the weight of the shot is to the square root of double the weight of powder, so is 1600 feet to the first velocity of the shot.

Ex. With what velocity will a 13-inch shell, weighing 196 lbs. be discharged by 9 lbs. of powder.

$\surd \frac{13}{196} \times 1600 = 485$ feet per second, nearly. *Ans.*
Or thus, $\surd\, 196 : \surd\, 18 :: 1600 : 485$ feet, nearly.

Prob. 2. To find the terminal velocity of a ball or shell; that is, the greatest velocity it can acquire by descending through the air, by its own weight.

Rule. For *balls*, the terminal velocity is found by multiplying the square root of the diameter of the ball in inches by 175·5; and for *shells*, by multiplying the square root of the diameter of the shell in inches by 147·3.

Ex. What is the terminal velocity of a 2 lbs. iron ball, its diameter being 2·45 inches.

$175{\cdot}5 \surd\, 2{\cdot}45 = 175{\cdot}5 \times 1{\cdot}56524 = 274{,}699$ feet. *Ans.*

Prob. 3. To find the height from which a body must fall, *in vacuo*, in order to acquire a given velocity.

Rule. Since the spaces descended by falling bodies are as the square of the velocities, and a fall of $16\frac{1}{12}$ feet, or 193 inches, produces a velocity of $32\frac{1}{6}$ feet or 386 inches, therefore 386^2: the square of the given velocity in inches : : 193 : height required in inches. Or, omitting the fractions, if the square of the given velocity in feet be divided by 64, the quotient will be the height required in feet nearly.

Ex. From what height must a body descend, in order to acquire the velocity of 1670 feet per second.

$1670^2 \div 64 = 43576$ feet. *Ans.*

Prob. 4. To find the greatest range of a ball or shell; and the elevation of the piece to produce that range.

Rule. Divide the given initial velocity by the terminal velocity of the ball or shell, and find the quotient in the first column of the following table; against which, in the second column, will be found the elevation to give the greatest range; and the corresponding number in the third column, multiplied by the height producing the terminal velocity, will give the greatest range nearly.

Elevations giving the Greatest Range.

Initial velocity divided by terminal velocity.	Elevation.		Range divided by altitude.	Initial velocity divided by terminal velocity.	Elevation.		Range divided by altitude.
	°	′			°	′	
0·691	44		0·3914	2·9725	37	15	1·2346
0·9445	43	15	0·585	3·226	36	30	2·3283
1·198	42	30	0·7787	3·4795	35	45	2·522
1·4515	41	45	0·9724	3·733	35		2·7157
1·705	41		1·1661	3·9865	34	15	2·9094
1·9585	40	15	1·3598	4·24	33	30	3·1031
2·212	39	30	1·5535	4·4935	32	45	3·2968
2·4655	38	45	1·7472	4·747	32		3·4905
2·719	38		1·9409	5·	31	15	3·6842

Ex. What is the greatest range of a 24 lb. iron ball, when discharged with a velocity of 1640 feet, and the elevation to produce that range, the diameter of the ball being 5·6 inches?

$175{\cdot}5 \surd\, 5{\cdot}6 = 415 =$ the terminal velocity.
$415^2 \div 64 = 2691 =$ the height producing that velocity.
$1640 \div 415 = 3{\cdot}95$, which nearly corresponds to 34° 15′ = the elevation required.

The range in the third column against 34°· 15′ is 2·9094, and $2{\cdot}9094 \times 2691 = 7829$ feet = the greatest range, nearly.

Prob. 5. The range of any one elevation being given, to find the range of any other elevation, and the converse.—*Rule.* As the sine of twice the first elevation is to the sine of twice the second, so is the range at the former to that at the latter, the velocity being the same in both cases.

Prob. 6. The range of one charge being given, to find the range for another charge, or the charge for another range.—*Rule.* The ranges at the same elevation are nearly proportional to the charges.

Ex. If, at an elevation of 45°, with a charge of 9 lbs. of powder, a shell range 4000 feet, what charge, at the same elevation, will be required to throw it 3000 feet?

4000 : 3000 : : 9 : $6\frac{3}{4}$ lbs. *Ans.*

Prob. 7. The range and elevation being given, to find the time of the flight.—*Rule.* As radius is to the tangent of elevation, so is the range in feet, to the square of 4 times the number of seconds taken up in the flight, nearly.

When the elevation is 45°, then $\frac{1}{4}$ of the square root of the range in feet will be the number of seconds required, nearly.

Ex. In what time will a shell range 3000 feet at an elevation of 35°? Rad : Tan 35° : : 3000 : 2100·6

$\frac{1}{4} \surd\, 2100{\cdot}6 = 11{\cdot}45$ seconds nearly. *Ans.*

Prob. 8. The range and elevation being given; to find the greatest height to which the shell rises above the horizontal plane.—*Rule.* As radius is to the tangent of elevation, so is $\frac{1}{4}$ of the range to the height required.

Ex. A shell, when discharged at an elevation of 40°, ranges 3000 feet; what is its greatest height during the flight?

Rad : Tan 40° : : 750 : 629 feet. *Ans.*

Prob. 9. The range and elevation being given; to find the impetus.—*Rule.* As the sine of twice the elevation is to the radius, so is half the range to the impetus.

Ex. With what impetus must a shell be discharged at an elevation of 35° to strike an object at the distance of 3180 feet? Sin 70° : Rad : : 1590 : 1629 feet. *Ans.*

Of Projectiles made on an Inclined Plane.—*Prob.* 10. The inclination of the plane, and the impetus and elevation of the piece being given, to find the range.—*Rule.* Add together twice the log. secant of the plane's inclination, the log. sine of the elevation above the plane, the log. co-sine of the elevation above the horizon, and the log. of four times the impetus; then will the sum be the log. of the range.

Ex. How far will a shot range on a plane which ascends 10°, and on another which descends 10°, the impetus being 2000 feet, and the elevation of the piece 32° 30′?

The elevation above the plane, in the first case, is 22° 30′, and in the second 42° 30′.

1st, *For the ascending plane.*	2dly, *For the descending plane.*
10°........ 2 sec .. 0·013297	10°........ 2 sec .. 0 013297
22° 30′ .... sin .... 9·582840	22° 30′ .... sin .... 9·829683
32° 30′ .... cosin .. 9·926029	32° 30′ .... cosin .. 9 926029
8000 ...... log..... 3·903090	8000 ...... log..... 3·903090
Range = 2662 feet = 3·425256	Range = 4700 feet = 3·672099

Prob. 11. The inclination of the plane, the range and elevation being given, to find the impetus.—*Rule.* Add together twice the log. co-sine of the plane's inclination, the log. cosecant of the elevation above the plane, the log. secant of the elevation above the horizon, and the log. of $\frac{1}{4}$ of the range; then will the sum be the log. of the impetus.

With what impetus must a shell be discharged to strike an object at the distance of 2662 feet on an inclined plane which ascends 10°, the elevation of the mortar being 32°·30′?

Plane's inclination..........10°......2 cos .. 10·986703
Elevation above the plane .. 22° 30′.. cosec .. 0·417160
Elevation above the horizon.. 32° 30′.. sec .... 0·073971
$\frac{1}{4}$ of the range.............. 665·5.... log. ... 2·823148

Impetus = 2000 feet, nearly = 3·300982

GUNPOWDER, a chemical mixture of nitre, charcoal, and sulphur, for the purpose of producing an explosive force by combustion, and thus communicating to guns of every caliber a prodigious power of projection. The first person who is said to have been acquainted with the nature and effects of a combination of these three materials in a certain proportion to each other was Roger Bacon. In his treatise "De Secretis Operibus Artis et Naturæ et de Nullitate Magiæ," cap. vi. published at Oxford about 1216, he informs us, that from saltpetre and other ingredients, we are able to make a fire that shall burn at any distance we please, which "other ingredients," it appears from some of his other manuscripts, were sulphur and charcoal. It was not, however, for a considerable time after this date that gunpowder became generally known; indeed it is very difficult, amongst the various contradictory accounts, to affix any precise date to this invention. Robins, in his "Gunnery," considers it as known before the time of Bacon, and that this philosopher mentions it not as a new discovery, but as the application of an old principle to military purposes, in which it had not been before employed. The proportions of the above ingredients, according to the best modern practice, is as follows; *viz.* 75 parts of nitre or saltpetre, 15 of charcoal, and 10 of sulphur. The specific gravity of which composition, at a mean, as stated by Count Rumford, is about 0·868, that of water being 1.

The method of ascertaining the strength of gunpowder is by a machine called an eprouvette, of which there are various constructions; but it commonly consists of a small strong barrel, in which a determinate quantity of the powder is fired, and the force of expansion is measured by the action excited on a strong spring or a great weight. Another method often adopted, is to fire a very heavy ball from a short mortar with a given weight of the powder, and to find the range of projection. The French eprouvette for government powder is a mortar of seven inches (French) in caliber, which with three ounces of powder should throw a copper globe of sixty pounds weight to the distance of 300 feet. No powder is admitted which does not answer this trial. Both these methods have been objected to: the former because the spring is moved by the instantaneous stroke of the flame, and not by its continued pressure, which is somewhat different; and the other on account of the tediousness attending its use, when a large number of barrels of powder are to be tried. Another method, which unites accuracy with despatch, is to suspend a small cannon as a pendulum, to fire with powder only, and to judge of the force of explosion by that of the recoil, which in this circumstance is a greater or less arc of a circle. That which Dr. Hutton employed on this principle, was a small cannon about one inch in the bore, the charge of which is two ounces of powder.

The cause of the explosive force of fired gunpowder has been much investigated; but it is now generally allowed to be chiefly owing to the sudden generation of a quantity of gas or elastic vapour. To determine the elasticity and quantity of this elastic vapour, produced from a given quantity of powder, Mr. Robins premises, that its elasticity is equally increased by heat and diminished by cold, as that of common air, (which is confirmed by Dr. Hutton's late experiments:) and consequently its weight is the same with the weight of an equal bulk of air at the same elasticity and temperature. Hence, and from direct experiments, he concludes, that the elastic fluid produced by the firing of gunpowder is nearly three-tenths of the weight of the powder itself, which, expanded to the rarity of common air, is about 244 times the bulk of the powder. Hence it would follow, that the mere conversion of confined powder into elastic vapour, would exert against the sides of the containing vessel an expansive force 244 times greater than the elasticity of common air, or, in other words, than the pressure of the atmosphere. But to this is to be superadded all the increase of expansive power produced by the heat generated, which is certainly very intense, though its exact degree cannot be ascertained. Supposing it to be equal to the full heat of red-hot iron, this would increase the expansion of common air (and also of all gases) about four times, which in the present instance would increase the 244 to nearly 1000; so that in a general way it may be assumed, that the expansive force of closely confined powder at the instant of firing is 1000 times greater than the pressure of common air: and this latter is known to press with the weight of fourteen pounds and a quarter on every inch; the force of explosion of gunpowder is 1000 times this, or 14750 pounds, or about six tons and a half on every square inch. This enormous force, however, is diminished in proportion as the elastic fluid dilates, being only half the strength when it occupies a double space, one-third of the strength when in a triple space, and so on.

Mr. Robins found that the strength of powder is the same in all variations of the density of the atmosphere, but not so in every state of moisture, being much impaired by a damp air, or with powder, which is become damp with careless keeping, or any other cause; so that the same powder which will discharge a bullet at the rate of 1700 feet in a second in dry air, will only propel it at the rate of 1200 feet when the air is fully moist; and a similar difference holds between dry and moist powder. Gunpowder is reckoned to explode at about 6000 of Fahrenheit's thermometer, but if heated to a degree just below that of faint redness, the sulphur will mostly burn off, leaving the charcoal unaltered.

Wightman, a gun-maker at Malton, in Yorkshire, says, the only certain way of computing the charge of powder for a fowling-piece is by weight, and not by the space it occupies in the barrel; and also the *quality* of the barrel should be expressed, for a difference in expansion makes a difference in the quantity required for a charge: for instance, the Damascus and common barrels, on account of their less expansibility than the twisted barrels, shoot equally strong with the latter when the charge of powder is reduced four grains; for it must be obvious to every one, that the shot could not be dislodged with equal force when the sides of the barrel yield to the sudden expansion of the exploded powder; and here I may add, that the shot travels with a much greater velocity than the rarefaction that moved it, which shews that the shot receives no accumulation of force by the quantity of powder which is put into the barrel, more than what is fired in the first instant, as the shot is propelled by the first rush of the air on the combustion of the powder.

The accompanying scale, he adds, is the result of trials made on several hundred guns.

Barrels are not so much distressed by firing balls, if the bore is cylindrical; the shot having a tendency to occupy a greater space, and therefore pressing hard against the sides of the barrel. In proof of this, the barrels of the guns used with shot are soon *leaded*, owing to the friction of the shot; but this is not the case when balls are used. The greatest objection, however, to the use of barrels of fowling-pieces for ball shooting is, that they are seldom sufficiently strong in the fore-end to prevent a vibratory motion, in which case the ball is thrown without any degree of precision. A ball of 19 to the pound exactly fits a 5-8ths bore, but a ball of 20 pounds, encircled in a thin piece of leather, is preferable.

The Damascus barrels are decidedly superior to the stubs twisted, or any other; the metal being stronger in texture, uniting better in welding, having little or no recoil, requiring a less charge of powder, and being more beautiful to the view.

The percussion-lock has every advantage over the flint-lock, namely, there is a less liability of accident by it, not being necessary to prime before loading, and the cock may be always kept on the cap except at the moment of firing, which prevents the gun going off at half cock; and if the gun is brought home loaded, by taking off the cap (which is the priming) there is no danger of its being fired by the foolishness of servants or others; and it is a fact, known to every observer of the percussion-gun, that they kill at ten yards farther than a flint-gun, and that about one-quarter less powder is used for a charge, owing to the complete and instantaneous combustion of the whole charge of powder; and that there is no loss of force through the touch-hole, as in the flint-guns; and also, that they receive the additional strength of the priming.

Caliber of Barrel.	Charge of Powder for a Flint Gun.	Charge of Powder for a Percussion do.	Quantity of Shot.	Distance to Kill.
5-8 inch.	1 dram.	¾ dram.	1¼ oz.	30 yds.
	1¼	⅞	do.	40
	1½	1⅛	do.	50
	1¾	1¼	do.	60
	1¼	1	1½ oz.	30
	1½	1¼	do.	40
	1¾	1½	do.	50
	2	1¾	do.	60
3-4	1½	1¼	1¾ oz.	30
	1¾	1½	do.	40
	2	1¾	do.	50
	2¼	2	do.	60

To Prove Gunpowder.—There are several ways of doing this. 1. By sight; thus if it be too black, it is a sign that it is moist. or else that it has too much charcoal in it; so also if rubbed upon white paper it blackens it more than good powder does; but if it be of a kind of azure colour, somewhat inclining to red, it is a sign of good powder. 2. By touching; for if in crushing it with the fingers' ends, the grains break easily and turn into dust, without feeling hard, it has not too much coal in it: or if, in pressing it under the fingers upon a smooth hard board, some grains feel harder than the rest, it is a sign the sulphur is not well mixed with the nitre. By firing a small heap of it on a clean board, and attending nicely to the flame and smoke it produces, and to the mark it leaves behind on the board.—There are other contrivances made use of, such as powder triers, acting by a spring, commonly sold at the shops, as the eprouvette.

To Recover damaged Powder.—Put part of the powder on a sail-cloth, to which add an equal weight of what is good: then mingle it well together, dry it in the sun, and barrel it up, keeping it in a dry and proper place. If it be very bad, restore it by moistening it with vinegar, water, urine, or brandy, then beat it fine, sift it, and to every pound add an ounce, or an ounce and a half, or two ounces (according as it is decayed) of melted nitre, and afterwards these ingredients are to be moistened and well mixed. But the operation of beating, or any species of friction, is extremely hazardous, and though we relate the method, we do not recommend the practice of this experiment.

Gunpowder and *Combustibles.* The laws respecting the manufacture and sale of these may be briefly expressed. No person shall make gunpowder but in the regular manufactories established at the time of making the statute 12 George III. c. 61, or licensed by the sessions. Only forty pounds of powder is to be made at one time under one pair of stones. Not more than forty hundred weight to be dried at one time in one stove. Not more than twenty-five barrels to be carried in any land carriage, not more than two hundred barrels by water, unless by sea or coastwise, each barrel not to contain more than one hundred pounds. No dealer to keep more than two hundred pounds of powder, nor any person, not a dealer, more than fifty pounds in the cities of London and Westminster, or within three miles thereof, or within any other city, borough, or market-town, or one mile thereof, or within two miles of the king's palaces or magazines, or half a mile of any parish church, on pain of forfeiture, and two shillings per pound, except in licensed mills, or to the amount of three hundred pounds for the use of collieries, within two hundred yards of them.

GUNTER, Edmund, an excellent English mathematician, who flourished in the reign of James I. and distinguished himself by his inventions, which have never yet been superseded, though some of them have been subsequently much improved.

Gunter's *Chain*, the chain in common use for measuring land according to the true or statute measure; so called from the name of its inventor. The length of the chain is 66 feet, or 22 yards, or four poles of five yards and a half each; and it is divided into 100 links of 7·92 inches each; 100,000 square links make one acre.

Gunter's *Line*, a logarithmic line usually graduated upon scales, sectors, &c.

It is also called the *Line of Lines* and *Line of Numbers*, being only the logarithms graduated upon a ruler, which therefore serves to solve problems instrumentally, in the same manner as logarithms do it arithmetically. It is usually divided into a hundred parts, every tenth of which is numbered, beginning with 1, and ending with 10; so that if the first great division, marked 1, stand for one-tenth of any integer, the next division, marked 2, will stand for two-tenths; 3, three-tenths, and so on; and the intermediate division will in like manner represent one-hundreth parts of an integer. If each of the great divisions represent 10 integers, then will the lesser divisions stand for integers; and if the great divisions be supposed each 100, the subdivisions will be each 10.

Use of Gunter's Line.—1. *To find the product of two numbers.* From 1 extend the compass to the multiplier; and the same extent, applied the same way from the multiplicand, will reach to the product.—Thus if the product of 4 and 8 be required, extend the compasses from 1 to 4; and that extent laid from 8 the same way, will reach to 32, their product.

2. *To divide one number by another.*—The extent from the divisor to unity will reach from the dividend to the quotient; thus, to divide 36 by 4, extend the compasses from 4 to 1, and the same extent will reach from 36 to 9, the quotient sought.

3. *To find a fourth proportional to three given numbers.*—Suppose the numbers 6,8,9: extend the compasses from 6 to 8; and this extent, laid from 9 the same way, will reach to 12, the fourth proportional required.

4. *To find a mean proportional between any two given numbers.*—Suppose 8 and 32: extend the compasses from 8, in the left-hand part of the line, to 32 in the right; then bisecting this distance, its half will reach from 8 forward, or from 32 backward, to 16, the mean proportional sought.

5. *To extract the square root of a number.*—Suppose 25: bisect the distance between 1 on the scale and the point representing 25; then half of this distance, set off from 1, will give the point representing the root 5. In the same manner, the cube root, or that of any higher power, may be found by dividing the distance on the line, between 1 and the given number, into as many equal parts as the index of the power expresses; then one of those parts set from 1, will find the point representing the root required.

Gunter's *Quadrant*, is a quadrant made of wood, brass, or some other substance; being a kind of stereographic projection on the plane of the equinoctial, the eye being supposed in one of the poles; so that the tropic, ecliptic, and horizon form the arches of circles, but the hour circles are other curves drawn by means of several altitudes of the sun for some particular latitude every year.

This instrument is used to find the hour of the day, the sun's azimuth, &c. and other common problems of the sphere or globe; as also to take the altitude of an object in degrees.

Gunter's *Scale*, usually called by seamen, the Gunter, is a large plain scale, having various lines upon it, of great use in working the cases or questions in navigation. This scale is usually two feet long, and about an inch and a half broad, with various lines upon it both natural and logarithmic, relating to trigonometry, navigation, &c. On the one side are the natural lines, and on the other the artificial or logarithmic ones. The former side is first divided into inches and tenths, and numbered from one to twenty-four inches, running the whole length near one edge. One half of the length of this side consists of two plane diagonal scales, for taking off dimensions for three places of figures. On the other half of this side are contained various lines relating to trigonometry, as performed by natural numbers, and marked thus; *viz.*

Rhumb, the rhumbs, or points of the compass;
Chord, the line of chords;
Sine, the line of sines;
Tang., the tangents;
S. T., the semi-tangents; and at the other end of this half are,
Leag., leagues, or equal parts;
Rhumb, another line of rhumbs.
M. L., miles of longitude.
Chor., another line of chords.

Also in the middle of this foot are L and P, two other lines of equal parts: and all these lines on this side of the scale serve for drawing or laying down the figures to the cases in trigonometry and navigation. On the other side of the scale are the following artificial or logarithmic lines, which serve for working or resolving those cases; *viz.*

S. R., the sine rhumbs;
T. R., the tangent rhumbs;
Numb., line of numbers;
Sine, sines;
V. S., the versed sines;
Tang., the tangents;
Meri., meridional parts;
E. P., equal parts.

GUNWALE, or Gunnel of a Ship, is that piece of timber which reaches on either side of the ship, from the half-deck to the fore-castle, being the uppermost bend, which finishes the upper works of the hull in that part, and wherein they put the stanchions which support the waist-trees. This is called the gunwale, whether there be guns in the ship or not. The lower part of any port, where any ordnance are, is also termed the gunwale.

GUST, a sudden and violent squall of wind, bursting from the hills upon the sea, so as to endanger the shipping near the shore. These are peculiar to some coasts, as those of South Barbary and Guinea.

GUT, in the West India islands, particularly in the island of Christopher's, or St. Kitt's, is a term for the opening of a river or brook, such river or brook also being often so called.

GUTTA SERENA, a disease in which the patient, without any apparent fault in the eye, is entirely deprived of sight.

GUTTER-LEDGE, a cross bar laid along the middle of a large hatchway in some vessels, to support the covers, and enable them the better to sustain any weighty body which may be laid on them.

GUTTERS, in Architecture, a kind of canals in the roofs of houses, serving to receive and carry off the rain.

GUTTURAL, a term applied to letters or sounds pronounced or formed as it were in the throat.

GUY, a rope used to keep steady any weighty body from bearing or falling against the ship's side while it is hoisting or lowering, particularly when the ship is shaken by a tempestuous sea.

GUY, is also the name of a tackle, used to confine a boom forward when a vessel is going large, and to prevent the sail from gybing by any accidental change of the wind or course, which would endanger the springing of the boom, or perhaps the upsetting of the vessel.

GUY, is likewise a large slack rope, extending from the head of the main-mast to the head of the fore-mast, and having two or three large blocks fastened to it; it is used to sustain a tackle to load or unload a ship with, and is accordingly removed as soon as that operation is finished.

GYBING, the art of shifting any boom-sail from one side of the vessel to the other. In order to understand this operation more clearly, it is necessary to remark, that by a boom-sail is meant any sail whose bottom is extended by a boom, the fore-end of which is hooked to its respective mast, so as to swing occasionally on either side of the vessel, describing an arch, of which the mast will be the centre. As the wind or the course changes, it also becomes frequently necessary to change the position of the boom, together with its sail, which is accordingly shifted to the other side of the vessel, as a door turns upon its hinges. The boom is pushed out by the effort of the wind upon the sail, and is kept in a proper situation by a strong tackle communicating with the vessel's stem, and called the sheet. It is also confined on the forepart by another tackle called the guy.

GYMNASIA, in ancient Greece, were edifices consisting of a great many separate parts or buildings for the accommodation of professors of the sciences or arts, and their hearers or pupils. Vitruvius, the Roman architect, gives the plan of the area of a Grecian Gymnasia, which the reader will find in his *Architecture*, or in *Potter's Grecian Antiquities*, vol. i. p. 45, Dunbar's edition. The parts of the Gymnasia were, 1st. The porticos or side buildings, furnished with seats, and fit for study or discourse, where the scholars probably met. 2d. The Ephebeam, where the youths exercised, or in which they assembled to fix on their sports and rewards. 3d. The undressing room. 4th. The place in which those who were to wrestle, or who had bathed, were anointed. 5th. The place where the dust was kept for besprinkling those who had been anointed. 6th. The Gymnasium, or place of wrestling. 7th. The tennis court, or ball ground. 8th. The discus and leaping ground. 9th. The Xysta, designed for the exercises of the wrestlers when the inclemency of the weather did not allow of practice in the open air. 10th. The baths, either hot or cold, for the refreshment of the combatants after their labour and toil. At Sparta, where nature was every thing, the sexes had one common bath; but in all other cities of Greece there were distinct baths for females. 11th. The stadium was the place of general exercise for performers and audience; and being built with benches rising one above another, allowed vast multitudes to assemble and witness the national pastimes.

GYMNASTICS. This word, derived from the Greek, comprehends all those athletic exercises by which the ancients rendered the body pliant and healthy, and enabled the muscles to do their offices with treble effect.

The principal exercises we here notice, as belonging to the ancient games, were *leaping*, *running*, *throwing*, *darting*, *wrestling*, *boxing*, and perhaps *swimming*.

Swiftness in running was one of the most excellent endowments a man could be blessed with, as is plain from Homer's constant character of the swift-footed Achilles. Saul and Jonathan were

> "Swifter than eagles, and stronger than lions."

The ancients practised leaping with oval weights placed upon their shoulders, or carried in their hands.

The *cestus* used on the hands in boxing, was the invention of Amycus, king of the Bebrycians, who was contemporary with the Argonauts, according to Clemens of Alexandria.

Thesus invented the art of *wrestling*, in which the antagonists had their bodies anointed with oil. In addition to these, the ancients had horse, chariot, and naval races, with swimming and diving, upon which we forbear to offer any description, but proceed at once to the modern Gymnastics, framed towards the close of the last century at Schnepfeuthal, a small town near Gotha, under the direction of Salzman, and subsequently improved, augmented, and systematically arranged by Gutzmuth, who published the first modern treatise on the subject in 1793. Gutzmuth not only attracted attention towards the importance of a systematic physical education; but in Denmark, in 1803, those exercises became national, inasmuch as 3000 young men were then practising there. Since that period, the Danish government issued an order, allotting 200 square yards of ground to every public school, as a Gymnasium. In 1810 Gutzmuth established his Gymnastics in Prussia, by authority of and under the protection of the government. M. Jahn, who undertook the management of this business in Berlin, soon promulgated Gymnastics in various parts of Germany. Gutzmuth published, in 1817, a complete system of Gymnastics, and the drawings, figs. 5, 6, 7, and 8, of the plate on Gymnastic Exercises, are taken from "A Military Officer's" abridgment of Gutzmuth's work.

In this country we have several *professors* of Gymnastics—of whom it will only be necessary to quote Capt. Clias, whose "Elementary Course of Gymnastic Exercises," illustrated by seventy engravings, is at once the most complete and systematic display of the physical powers of man that we have ever seen. In the sequel of this article we shall not attempt to draw a parallel between the abridgment of Gutzmuth's work and that of Captain Clias; but from both publications we will point out the exercises, and abstract such parts of their instructions as may serve the illustration of this subject in our own work.

In the division of Capt. Clias's work, the whole system of Gymnastics is reduced to four grand divisions,—first, as applicable to the lower extremities of the body; secondly, as belonging to the superior extremities; thirdly, complicated exercises, which require the united assistance of the muscles of the trunk and limbs; and fourthly, swimming.

Swimming we reserve till we come to letter S—article SWIMMING.

The "Instructions" by the "Military Officer," as reduced from Gutzmuth's book, and taught and practised in Germany, are the following.

Note.—The plan of the ground for exercise, which should always be designed by the master.

I. *Walking: Position of the Body in Walking.—Directions.* The position of the body must be upright and unconstrained; the breast thrown well forward, and square to the front; and the stomach drawn in a little, but not so much as to prevent a free breathing. The shoulders must be drawn back, and kept at an equal height. The arms must have a gentle, but perfectly free and natural motion by the side of the body. The head should be very upright, but without any stiffness; and ought to have a free motion from right to left, or upwards and downwards, as occasion may require, without causing any material alteration in the position of the body. The knees must neither bend too much, nor appear stiff. The toes must be turned out so as to form about half a right angle with the direction-line in

GYMNASTIC EXERCISES,

ANCIENT AND MODERN.

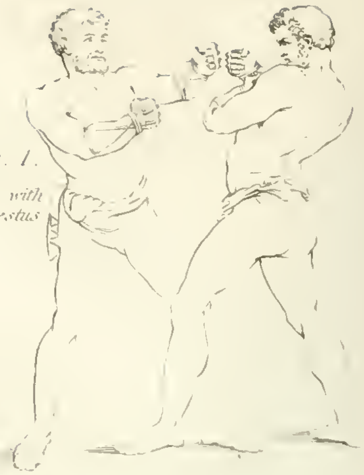
Fig. 3.

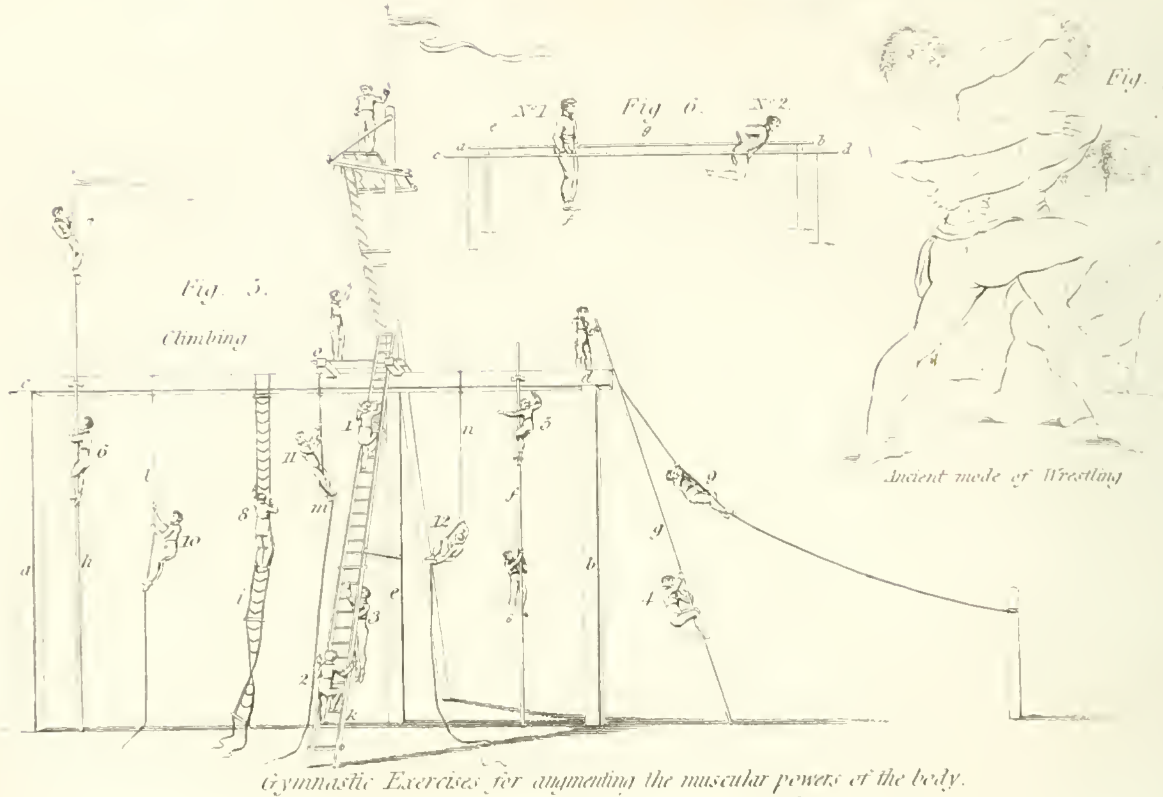
Ancient mode of Wrestling.

Fig. 2.

Fig. 1.

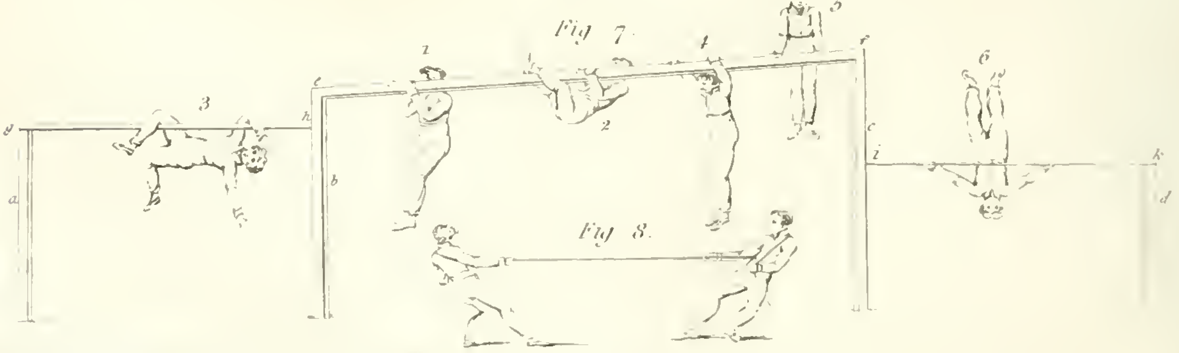
Boxing with the Cestus





Ancient mode of Wrestling

Gymnastic Exercises for augmenting the muscular powers of the body.



which the person is walking; and great care should be taken not to throw them upwards, but to keep the sole of the foot at the concluding part of the step, nearly parallel with the ground. The weight of the body should rest more upon the balls of the toes than upon the heels; by which means the whole position is rendered firm.

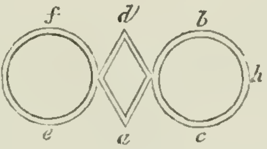
II. *Running*, in which the breast must be thrown well forward, and kept perfectly free. The upper parts of the arms are kept almost close to the sides of the body; the elbows bent, so that both parts of the arm may form, at this place, an acute angle; for the arms ought only to move to and fro in a very trifling degree, in order that the muscles connected with the breast may remain, as much as possible, at rest. At every step the knees are stretched out, and the tread must neither be entirely with the balls of the toes, since this would affect the calves too powerfully, nor yet with the whole sole of the foot.

Precautions.—Proceed gradually, as in all exercise. Choose a time when the air is cool. Take off your coat at the commencement of the exercise, and resume it the instant it is completed. Let the breast be either quite exposed, or very thinly covered. Wear a very light covering upon the head; a straw hat is best. The teacher should observe the runners, and let each cease as soon as a strong perspiration appears, and the breath becomes very short.—With these precautions, no fear need be entertained of the longest run.

Preparatory Exercises.—1. The teacher moves forward with his young pupils, at a moderate running pace, for five minutes. After they have frequently run over the ground, in this stated time, it must be gradually reduced; for instance, first to four, and then to three minutes.

2. Another piece of ground should be run over, at a moderate pace, during ten minutes, which time must also be gradually reduced as before.

In these exercises, the teacher must not reduce the stated times, so as to render the exercise too violent for the weakest of his pupils. He should also pay particular attention to their relative strength, in order to judge which of them are capable of completing the more difficult exercises.



3. In order to practise the pupils in turning, the teacher should form a figure upon the exercise-ground, similar to the annexed:—In running through this, they would be necessitated to turn the body suddenly in different directions. The direction to be taken by the runners, must be frequently changed by the teacher. They may also run in pairs, thus:—Two, of nearly equal strength, start together at a, the one taking the direction of a, e, f, to d, the other, that of a, c, b: he that reaches d first is the winner. The distance from f to h, should be about fifty feet, and that of a, d, about twenty-five feet.

Running is divided into the quick run, and the long run, which need no explanation: the only faults to be avoided are, that the steps be neither too long nor too slow, too short nor too quick.

III. *Leaping*, an excellent exercise for giving strength and agility to the lower members, has, as its preparatory exercises, the hop walk, the hop run, hopping, striking of the lower parts of the back with the feet, singly or doubly; and raising the knees.

Leaping is then divided into the high leap without a run, the high leap with a run,—the long leap, the jump with the run, spring, and descent,—the deep leap, performed either with or without the assistance of the hands.

IV. Those exercises for augmenting the muscular powers of the body and limbs, as performed on stands by Gutzmuth, are represented in figs. 6 and 7 of the plate Gymnastics, and if possible, they should be under cover, that the learners may be sheltered from either the rain or sun.

That shewn in fig. 6, is about five feet high, two feet in width, and of any convenient length; the upper surface of the bars a, b, c, and d, is rounded off so as to be more easily grasped by the hand. The other, in fig. 7, consists of four posts, a, b, c, d, of which b and c are about fifteen feet distant from each other, the one six, and the other seven feet high. The latter support a cross-piece, e, f, which is six inches deep, its lower side three inches wide, and its upper one about two; altogether it is shaped like the upper part of the rail of an ordinary staircase; g, h, and i, k, are two poles made of fir, eight feet long, and from two to two inches and a half thick: made round and smooth, and of different heights, for the convenience of the learners.

Exercise 1. The learner raises himself into the position shewn at No. 1, upon the stand a, b, c, d, and swings his legs backward and forward, the higher the better, as long as he possibly can; during which motion his feet will nearly describe the semicircle e, f, g.

2. When in the last position, the learner makes a jump, as it were, with his hands forward, and repeats it until he arrives at the end of the stand; whence he commences jumping backward as far as the other extremity. This, and the preceding, are two excellent exercises for strengthening the wrists.

3. The learner, after having raised himself into the position required in Ex. 1, lowers his body so as to bring his head nearly on a level with his elbows, which must be kept exactly over the bars. See No. 2. The most difficult part of the exercise follows; which consists in raising himself again into his former position. This exercise, which he should repeat as often as possible, is perhaps the best of any for strengthening the muscles of the chest, and particularly those which are connected with the shoulders.

4. As many of the learners place themselves in a row under the bar e, f, fig. 7, as can find convenient room; the tallest are nearest to the end f. The others who are not able to share in this exercise, help their companions up, so that they may seize the bar with both hands, and then leave them in that position. Each now supports his own weight with arms at full length, as long as he possibly can; which forms the first part of this exercise. The second is more difficult: it consists in keeping the elbows so much bent, that one shoulder remains close under the bar. Since it is not in the power of every beginner to raise himself to this position, the teacher must assist him until the required height is attained; it is sufficient for him to remain there but a short time at first. The exercise is rendered more lively by letting the learners try who can hang in this manner longest; but the teacher must prevent any one from overdoing it.

5. The hands are placed upon the bar, over opposite sides, as seen in No. 1. At another time they may be placed both on the same side. The learner now draws himself so much upward, as to be able to see over the bar, keeping the legs and feet closed and stretched out. He then lowers himself to the full length of his arms, and again raises his body. This exercise is very trying if often repeated. Most persons will go through it three, six, or perhaps nine times, but few reach the eighteenth or twenty-fourth time. It must not be carried too far, for the muscles are to be strengthened, not relaxed.

These two exercises should be frequently repeated, since they wonderfully increase the muscular powers, and greatly facilitate the succeeding exercises.

6. The learner hangs with his hands upon the bar, as before, and then raises and lowers the legs alternately. See No. 2. The hands are fixed on both sides, and at a little distance from each other; the elbows are very much bent; one shoulder is immediately under the bar, and the upper parts of the arms lie close to the body. The head now sinks backward, and at the same time the feet are raised so as to touch each other gently over the bar. From this they again sink into the hanging position. Beginners who have not thoroughly practised the two preceding exercises, find this one very difficult: some make a preparatory swing with the feet to assist them; but this is not correct, since the exercise ought to be performed entirely through the muscular force of the arms, back, &c. It can be repeated six, nine, twelve, eighteen, twenty-four, and even thirty times. The teacher is again recommended to prevent any one from overdoing the exercise: the pupils should not be impatient, but overcome every difficulty by practice alone.

7. Let the feet, when in the position of No. 2, as required in the preceding exercise, cling close to each other over the bar, and remain as long as possible in this position. The learners try to excel one another in this exercise.

8. Suppose the body to be in the last-mentioned position, *viz.* No. 2. Throw the right arm and right leg quickly over the bar, so as to hang to it by the elbow and knee joints, as seen in No. 3. Change the position with the same quickness by throwing the left leg and arm over the bar, in order to rest the other side. Finally, the body may be made to hang by the right leg and left arm, and *vice versa.* This exercise, which is performed upon the round bars *g*, *h*, and *i*, *k*, is rendered very pretty, by the position of the body and limbs being continually varied, and is very useful as a preparatory one to climbing.

9. Suppose the body to be again in the position of No. 2. Commence moving the hands one before the other, either towards *e* or *f*, and let the feet follow, either sliding along the bar, or what is much better, alternately changing like the hands, and retaining, in some measure, a similar hold. Continue moving along the bar in this manner, as long as your strength will permit.

10. The body hangs to the bar by the hands, placed as shewn at No. 4; these are then moved either forward or backward alternately as long as possible. This exercise is faulty when the arms hang straight and slack; or when the feet, instead of being quiet and close together, are violently drawn up and down. It may be varied by the learner's placing himself in front of the bar, hanging by both hands, and moving the latter alternately sideways.

11. When a person is in the position of No. 3, it is very easy for him to throw the left leg over the bar and across the right one; then let to go the arms entirely, and hang by the knee joints only. This exercise is perfectly safe, strengthens the knee joints, and is often useful in climbing.

12. The body being in the position of No. 2, the learner endeavours to sit upon the bar. The first attempts frequently fail, since some strength and agility are required. The easiest way of doing it is thus: suppose you wish, when in the position of No. 2, to get up on your right side of the bar; take a fast hold by the right knee joint, grasp firmly with the right hand, and bring the left arm over the bar so that the latter may be exactly under the armpit. From this position, the required or riding one is obtained with very little trouble.

13. When a person is in the riding position upon the bar, it is very easy for him to turn towards the front of the bar *e.f*; *viz.* by supporting himself upon one thigh, while the other leg hangs down. He then moves along the bar sideways, by raising his body with his hands, which are placed on the bar on each side of him. This exercise is very useful in practising a person to proceed a great way along a high beam.

14. The learner is in front of the bar, with his hands resting upon it, as in No. 5; he then removes his hands either to the right or left, and supports himself, in this manner, as far as he can along the bar.

15. Suppose a person to be supporting himself by the hands upon the bar, as before, No. 5; he then throws his head down forward, and dives, as it were; the middle of the body rests momentarily upon the bar, the feet swing upward, the whole person turns completely round, and the feet come to the ground. This is swinging round the bar forward; it is more difficult, but prettier, backward. Supported by the hands as before, the learner swings his feet once or twice backward and forward; when in the last swing he throws them quickly forward underneath the bar, forcing them upward on the opposite side, and then passes them over. See No. 6. In this he also rests momentarily with the middle of the body upon the bar, and then returns to his first positien. This swing round the bar backward is not easy at first; it requires a good deal of agility and exertion of the elastic force. The exercise should always be performed upon a smooth round bar, as *g*, *h*, or *i*, *k*. Exercises of this kind admit of numerous variations, and boys soon find them out; but the teacher should always stand by to observe them, and to give his assistance to any one who may require it.

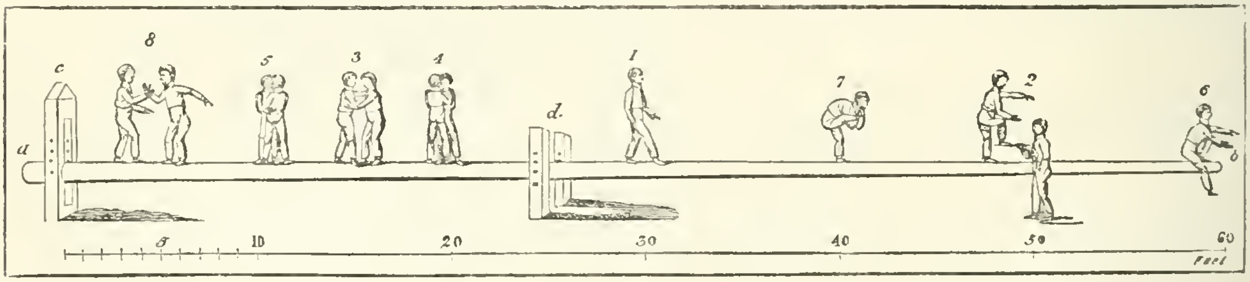
V. *Vaulting*, or raising the body from the ground quickly by a spring, and giving it at the same time such a swing by leaning the hands upon a fixed object, and poising the body if necessary, that the leap may be completed with facility. This exercise augments the flexibility of the arms and legs; it augments also the muscular powers of the body, and is serviceable in horsemanship, coursing, and numerous pastimes of youth.

VI. *Leaping with a Pole*, as the high leap, the long leap, the deep leap—all of which are a species of vaulting, in which the leaper carries a pole with him, which he places exactly upon any spot that offers itself, and upon which he supports himself during the leap.

VII. *Balancing*, the art of preserving a just equilibrium of the body in whatever position it may be placed, is a pleasing exercise confined to the lower extremities, or legs, and may be performed on the ground or on a bar.

The balancing bar consists of the stem of a tall and straight-grown fir, planed off quite round, about 60 feet in length, and placed in a level direction; see *a*, *b*, in the following figure. Its thickest end *a*, is supported by a post *c*, and may be raised or lowered at pleasure, by means of an iron peg, made to pass through the holes bored in the sides of the post. The stand *d* supports the bar somewhere about its centre, which can also be raised or lowered in this place. That part of the bar from *d* to *b*, remains without support, and consequently wavers when any weight is placed upon it. The upper surface of the bar is usually about 3 feet above the ground: it may be flattened a little about a foot from the extremity *b*.

The teacher conducts the pupil, by the hand, along the bar, a few times. The latter must keep his feet turned *outward*, and his body in an upright position. Little boys soon accustom themselves to walk upon the wavering end of the bar; they gradually take more courage, and learn to preserve their balance. After a short time, the teacher begins to give the pupil less assistance; instead of holding him fast by the arm, he now only allows him to touch the point of his finger, and at last only places his hand before him.



2. The learner walks along the bar, without the assistance of the teacher, (see No. 1,) who, however, remains by his side, at first, in order to observe the position of his body, and the placing of his feet, and also to assist him if absolutely required.

3. As soon as the learner is able to walk courageously along the bar, preserving a good position of the body, and also to spring off without falling, whenever he may have lost his balance, the teacher must render his walk more difficult, by placing obstacles, such as large stones, upon the bar, which he is either to step over, or to lift up; or he may hold a small

stick before him, about the height of his knee, and make him step over it. See No. 2. The exercise is made more difficult by obliging the learner to hold his hands across his breast, instead of using them to assist in keeping his balance.

4. Hitherto the learner has been accustomed to walk from *a* to *b*, and to jump off from the latter extremity; but the teacher now makes him *turn round* at *b*, and return to *a*. He ought, however, to have previously learned to turn himself well upon the thick end of the bar.

5. The pupil walks backward upon the bar; an exercise which is not at all so difficult as it appears, if he have acquired sufficient expertness in the preceding ones.

6. Two learners meet upon the bar, and wish to pass each other. They hold one another fast by the arms, and advance breast to breast. Each places his right foot forward, close to that of his comrade, across the bar. See No. 3. They count 1, 2, 3, and turn completely round one another at the word *three*, each making a step with his left foot round the right one of his comrade, as the two learners have already done at No. 4. The two learners represented at No. 5, are turning themselves round after having placed the left foot in front; and have completed the turn, except the withdrawing of this foot.

7. This is a repetition of a preparatory exercise to vaulting, applied to the balancing bar. When performed upon the wavering part of the bar, it is an excellent exercise in balancing. The learner should, in repeating it, advance nearer to the end *b* of the bar.

8. This is a repetition of some preparatory exercises, *viz.* the sitting down and standing up on one leg, applied to the balancing bar. See No. 6. At one time, the right, at another, the left leg is lowered. When this exercise is performed at the extremity of the bar, as in No. 6, a great deal depends upon the steady position of the body. It is necessary that the teacher should stand close by the learner, in order to assist him in case of his falling.

9. It is not difficult, when standing upon that part of the bar where the wavering is slight, to raise, by aid of the hands, one foot so high, (lowering the head at the same time,) as to be enabled to kiss the toe, as shewn in No. 7. When the learner is expert in this, let him attempt it on the wavering end of the bar, where it is much more difficult. The foot is placed upon the bar, in the direction of the latter. The learner waits until all wavering has ceased; he then raises the foot slowly and steadily, and bends forward, taking great care all the while to preserve his balance. He seizes the foot quickly, but without making much motion, and conducts it to the mouth. Upon returning his foot to the bar, he should stand very steadily upon it.

10. Two learners meet upon the bar, and each endeavours to push the other off, by using one hand. See No. 8. The learners must recollect they are not to give a hard blow, but rather a push, keeping the arm stiff. This exercise teaches them to maintain their position upon a narrow round surface.

11. A support is placed under the end *b*, of the bar, and the iron peg which supports the latter in the stand *d*, is removed. All the learners then walk along the bar, at the distance of two paces behind each other. This exercise instructs the learners in crossing a river or ditch by means of a long pole.

In walking along the bar, it is necessary to turn the feet outward, so as to keep them more across it than in its own direction. By observing this, the pupil is much less liable to slip. 2. As the upper surface of the bar is generally too smooth in very dry weather, the soles of the shoes should, in that case, be damped by rubbing them upon a wet spot of ground. 3. From the nature of these exercises, it is evident that they should never be performed with violence or rashness, but rather with patience and caution. If the bar swings too much, you should wait until it is steady, before you continue what you have begun. 4. The ground about the bar should consist of sand. 5. The teacher should always stand near the beginner to give him assistance. 6. No voluntary swinging of the bar, on the part of the learners, must be allowed.

VIII. *Climbing and Mounting.* These arts are of the utmost importance to the military, maritime, and civil inhabitants of Britain. The soldier who has been well taught in the gymnastic school, has an immense advantage over both his comrade and his enemy, in case of an attack upon a place difficult of access, such as the storming of a town, or the carrying of a commanding height. The sailor's life is spent in climbing, and he would always feel the benefit of early instruction in these practices. The traveller, afraid of danger or fatigue, passes rocks or mountains commanding the most beautiful prospects, which, if well instructed, he might ascend with ease and pleasure, and the inhabitant of the city would sleep more secure from the apprehension of fire, if he felt confident in being able at the shortest notice to descend the loftiest and most awkward elevations. Such security may be promised to him who has mastered the gymnastic art, as practised in various parts of Germany, and as now taught in England.

The Climbing-stand. This, with all its appurtenances, is represented in the Plate, fig. 5. It consists of two strong posts *a* and *b* firmly fixed in the ground; 20 feet high, and about 30 feet distant from each other. They support the beam *c d*, which is strongly fastened to them. The mast *e*, is fixed upright and very firmly in the ground, and in such a manner as to pass close by the beam *c d*, to which it may be attached by means of an iron band; though this is not necessary if it be supported by the slant post *q* on the other side of the stand. To the beam *c d*, are attached the implements for climbing; *viz.* two poles *f* and *g*, three ropes *l*, *m*, and *n*, a rope ladder *i*, and a mast *h*. The two standing-places *o* and *p* are intended for the exercises in mounting. A ladder leads to the lower one, and is made fast to the mast *e*; another leads from the lower to the upper one. The firm construction of these standing-places must be executed under the eye of the teacher: the upper one *p* may be dispensed with if the latter thinks proper; it is merely intended for the purpose of strengthening the nerves of the learners by accustoming them to look down from a great height.

Climbing by means of both Arms and Legs. The teacher must require the learners to be expert in the exercises given in Section IV. pages 425 and 426, before they commence the following ones, to which they may be considered as preparatory.

1. Beginners ascend and descend the ladder which is fixed to the climbing-stand, in the customary way, until they acquire expertness and courage.

2. They descend with the back turned towards the ladder.

3. They mount and descend in the usual way, but only with one hand; and, after a little practice, carry something in the other. See No. 1.

4. The learner goes up and down without using his hands. See No. 2. The ascent is extremely easy; after which he uses his hands in turning round so as to have his back towards the ladder when descending. In this part of the exercise, the teacher must always be ready to assist him.

5. Two learners meet upon the ladder, and wish to pass each other. They either both remain on the front part of the ladder, and give way to each other as much as possible, or, if one of them is sufficiently expert in the two following exercises, he swings himself round to the back part, in order to let his companion pass.

6. The exercises now commence on the back part of the ladder. The learner easily ascends from step to step by advancing his hands and feet, at the same time, higher and higher.

7. The learner mounts along the front part of the ladder as usual; then swings himself round to the back part, along which he descends.

8. The learner mounts and descends the ladder upon its back part, without making use of his feet. See No. 3. Although this exercise ought not, strictly speaking, to be introduced here, yet as we are busy with the ladder, there will be no harm in mentioning it now. It may be divided into two parts. The first consists in taking fast hold of the most convenient rundle with both hands, and raising the body forcibly upward. At this moment, one hand seizes the next highest rundle, and immediately afterwards, the other hand does the same. Both hands again raise the body as before, &c. In the second part of this exercise, the hands seize the rundles singly and alternately; which is much more difficult, and only accomplished by practised learners.

9. *Climbing either the Upright or Slant Pole.* The thickness

of the upright pole *f*, is from two to two inches and a half, or more, according to the size of the learners. It must be perfectly smooth, and void of splinters. Its upper end is fastened by an iron ring to the beam *cd*. The slant pole *g* must be at least three inches thick. Neither of them is made very fast in the ground, but only sunk a little into it, in order that they may be easily replaced by poles of different sizes. The position of the climber is the same in both the upright and oblique pole, and is shewn upon the latter, in No. 4. Nothing must touch the pole besides the feet, legs, knees, and hands. The climber, while he raises himself with both hands, draws his legs up the pole, as in fig. 4, then holds fast by them, and again places his hands higher up. He continues this alternate use of the legs and arms until he has reached the top. The descent is not at all difficult; it is not performed similar to the ascent, but merely by sliding quickly down with the legs, without scarcely ever touching the pole with the hands, as shewn in No. 5. This exercise is more difficult upon the oblique pole, since the hands are more affected by the weight of the body. The learners should be made very perfect in this exercise, for every one ought at least to be sufficiently expert in case of fire to slide himself down along a smooth pole placed against the window of a second or third story of a house.

10. *Climbing the Mast* is more difficult than the last exercise, for even when made of a moderate size, it cannot be spanned round by the hands. It is fixed quite firm in the ground; is from six to eight inches thick at the bottom, and thirty feet high. The learners must not be allowed to climb the mast until they are very expert at climbing the poles mentioned in the last exercise, and are able to get from that, upon the beam *cd*. All climbing succeeds best in hot weather, but more particularly that of the mast. The position of the legs is the same as with the pole: boots are the best covering for the feet. Since the mast is too thick to be grasped by the hands, the climber must lay fast hold of his left arm with his right hand, and *vice versâ*. Learners climb with much more ease and security, with naked arms, for the skin does not slip near so easily as the clothes. A climber up the mast adheres to it with his whole body, as in fig. 6, until he reaches the thinner part of it, as appears from No. 7.

11. *Climbing the Rope-ladder.* (See *i*, in the Plate.) The rope-ladder should have three or four wooden rundles to spread it out, and ought to be made so as not to twist round and entangle when used; if it has this fault, it is unserviceable.

It is much more difficult to mount the rope-ladder than the pole, the former hanging quite loose, and not at all fastened at the bottom. The muscles of the arms and hands are very much affected; for the latter must, when the learner is not sufficiently acquainted with this exercise, almost entirely support the body, which continually inclines backward. The manner of proceeding in this exercise is easy, for it is similar to ascending a wooden ladder; but as the rope-ladder hangs perpendicularly, and is very flexible, the steps upon which the feet rest, are generally pushed forward by the unpractised, and the upper part of the body sinks out of the perpendicular position into a very oblique one; whereby the whole weight of the body becomes supported by the hands, and the exercise is rendered so difficult that the learner cannot ascend very high. To obviate this, he must always have a fast hold of the two main ropes, as shewn in fig. 8, and keep the body, as much as possible, stretched out upon the ladder and upright. If the ladder is sufficiently strong, the teacher allows two or three of his pupils to get up and down at the same time; by which means they learn to pass each other. One hangs by a main rope until the other has passed him.

12. *Climbing either the Oblique or Level Rope.* Let a rope be fastened from one post to another, or from the beam *cd*, to an adjoining post *k*, and in an oblique direction. Another might also be placed in a level direction, having one end fastened at *k*, and the other to the post *b*. In either case the learner fixes himself to the rope as in No. 9, in the position required in Exercise 7, Section IV; and advances along the rope in the way required in Exercise 9, Section IV. In this manner, a number of soldiers might cross a small river, with their arms and knapsacks, when other means failed.

There are two ways of using the legs in this exercise; 1st, exactly as in Exercise 9, Section IV., so that the feet, either in ascending or descending, move forward along the rope alternately; or one leg only may hang over the rope, and be made to slide along it; but in both cases the pressure is painful, particularly if the climber does not wear boots. The 2d, which is the best method, is to place the sole of one foot, for instance, the right, flat *upon* the rope, and to lay the left leg across the instep of that foot; whereby the friction of the rope is removed.

13. *Climbing the Upright Rope.* This exercise is shewn in the figure, upon two ropes *l* and *m*, because the securing of the rope by the feet may be done in two different ways. It is very easy to those who are already expert at climbing the upright pole. The only difficulty lies in seizing the rope with the feet so as to obtain a firm support.

The first method is shewn in No. 10, upon the rope *l*. Knees and thighs have nothing to do here; only the feet are employed. If the learner sit upon a chair, and cross his feet in the usual way, he will immediately perceive their proper position. The rope passes between them, and is held fast by pressing them moderately together, while the hands alternately grasp higher up the rope. Hereupon the climber, hanging by his hands, also draws his feet higher up, fixes them again to the rope, and proceeds as before.

The second method, peculiar to sailors, is shewn at No. 11, on the rope *m*. The rope passes down from the hands of the climber, along one, generally the right, thigh, not far above the knee; winds round the inner side of this thigh, along the knee-hollow and the calf, and then across the instep of the right foot, whence it hangs loose. If the climber only treads moderately upon that part of the rope where it crosses the other foot, he will, by means of the varied pressure, obtain a firm support. The exercise depends almost entirely upon holding the right leg and foot so that the rope may retain its proper winding, after being quitted by the left foot, when the hands have been raised for the purpose of drawing the body higher. This is easily acquired after a few trials. In descending, the hands must be lowered alternately, as they are raised in ascending, for if the hands slide down quickly, they will be injured.

14. *Resting upon the Upright Rope.* This exercise not only excites a lengthened power of the muscles, but also tends to promote expertness in dangerous situations. It is represented in the figure, at No. 12, upon the rope *n*; which must be much longer than what the height requires. The climber mounts to a moderate height, and then haults; swings the right foot three or four times round the rope, so that this winds round the leg; he then entwines it, by means of the left foot, once or twice round the right one, which he bends so as to point the toes upwards, and now treads the left foot firmly upon this last winding. The pressure which thus arises between the rope and the feet, opposes the whole weight of the body. In this position, he can rest a long time: but suppose he wishes to be still more at his ease; with this intention, he lowers his hands a little along the rope, as shewn in fig. 12, then holds fast with the right hand, stoops, and grasps with the left, that part of the rope which hangs below the feet. He raises himself again, and entwines this part a few times round his shoulders, hips, and the rope itself, until he is firmly entangled.

15. *Climbing Trees.* The preceding exercises have been applied to objects made very firm and secure by art, and were therefore, after good preparatory ones, attended without danger. It is otherwise with trees: their branches frequently give a very insecure support; the nature of the wood must be considered; consequently, this kind of climbing requires, with beginners, the careful attention of the teacher. The danger does not consist in clambering up the stem of the tree, but in climbing from one branch to another.

Precautions. The teacher must only allow the learner to climb up low branches at first, so that he may narrowly observe his movements. He must stand by, and warn him from the branches which appear insecure, and make him acquainted with the important rule, to support himself almost entirely by the *hands*, and not to confide too much to the feet, since they easily slip from off the branches. Beginners must not be allowed to perform this exercise in winter, for then the withered branches are not so easily distinguished.

The different advantages which must occur to the learner in this exercise, increase with his agility and courage. He is soon enabled to pass from the branches of a tree to those of an adjoining one, and so on along a whole row. If he have had sufficient practice with the rope, he will not always clamber up and down the stem of the tree, but seize a sufficiently strong branch, which hangs low enough to be reached from the ground with his hands, and swing himself either up to, or down from it. Should this branch be somewhat higher, he can make a preparatory run, and catch it immediately after having made a spring.

To render this exercise more agreeable, and to try, at the same time, the expertness of the learners, the teacher may sometimes take them to a group of trees; he then counts 15, and during his counting, each exerts himself to climb so high up a tree as to be without the reach of the teacher's stick; the endeavouring to escape which excites great laughter.

Climbing by means of the Arms only. This is one of the best exercises for strengthening all the muscles of the chest, the arms, and hands; it is a true criterion by which to judge the powers of these members, and it also augments them most effectually. We seldom find a boy who is able, in his eighth or ninth year, to raise himself a little way either up the rope or pole by his hands only. The age of fourteen is generally the time when the arms become sufficiently strong; therefore some attention must be paid to this point, with respect to the learners. The best preparatory exercises are the 5th and 10th in Section IV. The exercise itself may be applied to the *ladder*, (as already given in Exercise VIII.) to the *pole*, and the *rope*, either slanting or upright.

Ex. 1. *Climbing up the Pole by the Hands only*, is perhaps easier than up the ladder, for with this the body hangs quite free, but with the former one side of the body is close to the pole, which facilitates the learner a little. See No. 13. When this exercise is applied to the *upright pole*, the position of the body will be good, if similar to that represented at fig. 13. The feet hang loosely, and remain perfectly steady. The climber must not be allowed to bend his knees, nor to stamp, as it were, in the air, nor to let the pole come between his thighs. There are two methods of employing the hands in this exercise. According to the *first*, which is the usual mode, both hands raise the body simultaneously; immediately after which, one quickly grasps the pole higher up, while the other supports the weight alone for a moment. The *second*, in which each hand alternately supports the body *alone*, and the other, quite free, seizes the pole higher up, in order to raise the body again, requires great practice and considerable strength in the arms. In climbing the slant pole, the position is similar to that in the 10th Exercise, in Section IV.

2. *Climbing the Rope by the Hands only*, should be first practised upon the slant rope, as with it, the continual grasping higher up is much easier. The position of the hands and of the body similar to that required in climbing the pole.

It should be observed, that of the preceding exercises, all those which require more strength and agility must not be kept up too long. Strength increases gradually, its growth is not only combined with exercise, but also with the development of the corporeal system. For this reason, such exercises should be *frequent* but *not long*.

Exercises in Mounting. These exercises require neither particular strength nor agility; they are intended to produce fearlessness, and the power of looking down from high stations, and consequently to prevent weakness of nerves and giddiness. The teacher will have little difficulty with boys accustomed to the country, but he must pay great attention to those who come from large cities, as they are frequently weak, nervous, and timid. If any one of them is sufficiently strengthened by the preceding climbing exercises, and becomes bolder in climbing the pole and the ladder, he may mount the first standing-place *o*. If he be very timid, then even his climbing to the top of the pole will be no certain proof of his having lost his timidity, for the firmness with which the climber clings to the pole, gives him a security which renders him fearless; he may still be afraid of standing quite freely upon the ladder or the standing-place. Such a one must only ascend higher up the ladder gradually, turn round, and sit down upon a rundle, in order to accustom himself to look down for a long time upon the ground. If he finally climbs the pole *f*, so as to place himself in the riding position upon the beam *c d*, and can look down with indifference, he may then fearlessly get upon the lower standing-place. But whoever can ascend the beam from the pole, the rope, and the rope-ladder, and can shake the fane of the mast, (see No. 7,) may mount with confidence the upper standing-place *p*.

IX. Wrestling exercises both legs and arms, excites every muscle, strengthens the chest, circulates the blood, and gives youth courage, patience, and perseverance. It may be said to consist of *heaving*, fig. 4, *pulling*, fig. 8, and fighting upon the ground, on which the combatants used voluntarily to throw themselves down, as shewn in figures 2 and 3. This was the ancient mode, in which pinching, biting, scratching, and luxation, formed legitimate means of vanquishing an adversary. We have in modern wrestling altered these Grecian customs, where the virgins were taught to dance in public at certain festivals, to wrestle with each other, as in either or all the three groupes of wrestlers on the Plate, to run with the utmost speed over the adjoining country, to shoot with the bow, and to launch the javelin; and all these exercises they performed with scarcely any clothing to encumber them, and without any feeling of shame, for Lycurgus thought that where there was no concealment, there was no temptation. See Tuscul. Quæst. lib. 3, for Cicero's description of the pursuits of these daughters of liberty.

We proceed now to consider Gymnastics as tending to preserve or to re-establish health, by a development of the moral faculties and physical powers of man. This is the view which the politician and schoolmaster should take of this art, for the posture master can regulate the movements of the human body, and the Ourang-Outang has far more agility and pliancy of muscular power than man. But the study of gymnastics is inseparable also from that of medicine; at any rate, the art of healing abandoned the temples, and took refuge in the academies or schools; and although Captain Clias be not a physician, he has given his work quite a medical turn, interesting, above all praise, from the edifice he rears, appropriating its parts to the wants of life, and to the laws of living economy. I speak from actual observation of this gentleman's instructions to the young men at my own school. His constant study seems to be, to determine the most convenient methods for strengthening the powers of each organ, and to increase the energies of the vital properties. With this view, he has contrived exercises peculiar to the action of each part of the body; and he begins at first by the most simple motions, to arrive progressively at the most complicated.

In speaking of gymnastics, we are not here contending for these exercises as preservatives of health, but what is most important, as applicable in all the different kinds of dangerous and morbid disorders. And the injuries that appear capable of yielding to a well-combined and methodical movement of the lower extremities, are lumbago, sciatica, the imperfect anchiloses, sprains, a bad construction of the legs and thighs, palsies, stiffness, rheumatisms, gout, &c. These and other morbid affections ought wholly or in part to give way to a frequent exercise of the arms, when they have taken their direction towards the upper regions; but as the action of the muscles of the arms is almost always simultaneous with those of the thorax, the same exercises will naturally correct a number of disorders and deformities with which the chest is threatened. Thus, obstinate coughs, recent asthma, tendency to a curved spine, and the vitious formation of the thorax, &c would find, in a great variety of these movements for the arms, an advantage that would be vainly sought for in the usual mode of treatment. So we are confident of the salutary effects resulting from the same practice on the visceras of the abdomen

I have seen about 200 different exercises performed agreeably to Captain Clias's directions, of which not one could be classed among the games and pastimes of Scotland and England. And the great merit of these exercises appears to me to be, that, while the end of each is to increase the elasticity of the articulation, (*i. e.* the joints,) to favour the development of the muscular powers, to strengthen the body, and facilitate standing and moving in any attitude, without losing the equilibrium,—they teach youth also to brave and avoid dangers, and to overcome obstacles, which, to others, would be insurmountable.

I. The following is a sketch of the exercises applicable by Captain Clias to the lower extremities.

1. *Walking, running, jumping*, which he divides into walking in general, preparatory movements, and the following exercises:

1. The ordinary step.
2. Changes in place.
3. The double step.
4. The triple step.
5. Oblique and cross step.
6. The French step.
7. Walking on the heels.
8. Kicking.
9. The broken step.
10. The ticktack.

It is easy to perceive how much these exercises contribute to develope the force, the suppleness, and the agility of the lower extremities; as the hip, the knee, the muscles of the thigh, which make the movement, are the parts most fatigued.

2. *Balancing* on the feet may be considered introductory to dancing, and its exercises are ten:

1. Balancing on one leg.
2. The school step.
3. The pace of three times.
4. First balance.
5. To touch the ground.
6. The cross touch.
7. The touch of the toe.
8. The touch of the heel.
9. Changing the guard.
10. Walk near the ground.

3. *Running*, which, from preparatory movements, carries the pupil through ten exercises:

1. Running in place.
2. Rising and crouching.
3. Running in a square.
4. Spiral running.
5. Sinuous running.
6. Doubling the line.
7. Running with a stick.
8. Running moderately.
9. Prompt running.
10. Precipitate running.

Captain Barclay's walking 180 miles without resting, and still more, his doing 1000 miles in 1000 successive hours, afford strong proofs of what may be effected by persevering exercise; and are unparalleled to any exercise of the kind of which foreigners can boast.

4. *Jumping in general*, embraces

1. Preparatory movements.
2. Rising & touching behind.
3. Trampling on the ground.
4. Walking pace in place.
5. Trotting pace in place.
6. Galloping pace in place.
7. Simple jumping in place.
8. Redoubled jumping.
9. Continued jump.
10. The spectre's march.

If the volume, strength, and suppleness of the members are increased, by means of exercises, there are none more proper for developing the lower extremities than these four sections. The details of these exercises occupy 60 pages of the original work before me; and a judicious gymnasian would, without doubt, vary and modify them in a thousand circumstances, of which he only can be the judge.

II. The exercises of the superior extremities upon the plan of Captain Clias, embrace

1. The *Movement of the Arms*, consisting of these exercises:

1. Raising them straight in front, parallel to the ears.
2. The oscillatory, or pendulum movement.
3. The circular, vertical, and superior movement.
4. Developing before, striking behind, and detaching sideways.
5. Swimming motions—the thrust—circling—hovering—pointing to the ground.

2. *Complicated Movements of the Arms and Feet* together, in place or moving forwards and backwards, may be executed by persons of all ages, and in every station of life; for by their quick and rapid action, of short duration, but frequently repeated, they are calculated to give strength alike to the youth and the adult, by making them active and pliant in their limbs, enabling the grown man to maintain an equilibrium between the body and mind, and the old man to warm his vital powers, which are perhaps nearly extinguished.

The third chapter of the work of Captain Clias, treats of complicated exercises in a series of twelve different ways of climbing, wrestling, swimming, and vaulting. We arrive at wrestling, according to this system, by a course of preparatory exercises that serve as its introduction: as,

1. Kissing the ground in equilibrium, on the arms and the points of the feet.
2. To the ground backwards, by supporting the body on the hands and heels.
3. The seven or square.
4. The goat's jump.
5. Squaring with the hands, or wrestling with the fists.
6. Head to head.
7. Binding.
8. Bending upwards.
9. Wrestling with sticks.
10. Forming the lever.
11. The snares, or the trip.
12. Taking the advantage.
13. The first fall.
14. Wrestling on the ground.

We forbear the description of each of these exercises, and observe that they are all the natural pastimes of youth, which only require to be directed by a man capable of appreciating the different dispositions of his pupils, in order to match them conformably to their strength, agility, and courage.

Jumping, running, and *skipping in a hoop*, developes itself by passing the hoop forward, in place; passing it behind; running through the hoop; making the half-passage sideways, in place; the entire passage, and the return or passing above, which are all simple, amusing, and healthful exercises for boys at school.

Jumping, running, and *skipping with a chord*, is a well-known exercise, which might be regulated to passing before or behind, in place; passing before in running; skipping in place; simple passing and crossing, in place; three alternate jumps, simple, double, and crossing; doubling right and crossed, and doubling the cross. But, in short, elementary exercises of the lower extremities may be varied every hour during the years of pupilage.

Among the complicated exercises belonging to the lower extremities is *skating*, for which *see* SKATING.

Elementary vaulting and the *parallel bars*, are also reserved to VAULTING.

The combination of all these exercises forms one of the most complete systems for developing the muscular and physical powers of man, that can be devised in a medical and political point of view. The articles *skating, swimming*, and *vaulting*, which we have reserved for their proper places, will disclose the whole of the Gymnastics of Captain Clias, and they will be accompanied with engravings illustrative of the exercises.

We do not know that we can add any thing more pertinent on this subject, than the following remarks, which occurred in a periodical publication, which, though it considered the book of Captain Clias more circumstantial, perhaps, than was absolutely necessary, yet admitted that the subject was deserving of attention, in as much as the close confinement incidental to the pursuits (as well as dwellings) of men who live in populous cities, joined to the difficulty of finding convenient fields for air and exercise, soon tends to produce an indisposition to active amusements. The inhabitants of London took great pains to correct this mischief, two centuries ago, by especially promoting all such games, and festivals, and diversions, as were calculated to carry their youth into the open air, and to induce habits of activity and bodily vigour. In fact, king James the First was himself a great promoter of Gymnastics, as may be amply seen in Strutt's Sports and Pastimes of the People of England; but then came Oliver Cromwell and his sour-faced, canting Puritans, who put an end to these rational amusements. Let that pass, and turn we to the advantage of the course which Captain Clias has established, and which, too, has been fully admitted of late years in most considerable schools; where lads are stimulated, and even compelled, to run, leap, swim, and join in other vigorous and manly diversions; and although it may appear at first that these are matters to require merely encouragement rather than instruction, still any thing like a system not only always forms the best kind of encouragement, but produces results far more rapid and decisive than any desultory attention can do. Therefore, though we do not go the full length of Mr. Clias's scheme—such as to perceive the convenience of teaching "young ladies" to swim, or quite understand what persons he proposes should become their instructors—it is worth considering whether the employing part of their leisure hours in the practice of vaulting, running, jumping, and such vigorous and healthful movements, is not likely to do lads from fifteen to twenty years old more good than breaking lamps in the street—(the only "gymnastic" exercise at present in repute)—or making nuisances of themselves (more than need must be) in the passages of minor theatres. The evolutions suggested seem, without exception, to be very simple, safe, and extremely well calculated to improve the various muscular actions of the body, particularly as regards lads who are intended for the army or navy. The habit of steady firm walking is of itself alone an important acquirement; running, jumping, and wrestling, are also taught, and the climbing of ropes and poles. Swimming, as regards London, could only be taught in particular places; but one of Mr. Clias's hints on the subject—the advantage of practising constantly in a light jacket and trowsers—seems not only to be very just as regards the circumstance under which men are generally most peremptorily called upon to swim, but would go to facilitate bathing in many situations where it is now impossible. On the general question, there can be but one opinion as to the advantage of using all exercise which tends to increase or develop the powers of the human frame. In fact, that which we call courage, nineteen times in twenty, lies merely in a man's knowledge of, or confidence in, his own faculties, as the contrary feeling as generally arises from a distrust or consciousness of the want of them. There can be no reason but this, why one man should feel quite at home with a sword in his hand, who finds great discomfort in boxing; or another fight a bull with all the pleasure in the world, who would not at all like to meet a Thames-street carman. In the same way, it is matter of common observation, the readiness with which those classes accustomed to violent labour always enter into personal conflict, because, in point of fact, their daily occupation is a description of conflict; and so again we have cases every day of prize-fighters by profession, whose whole "fight" lies in a confidence in their own strength and skill; and who—fancying themselves over-matched in the least point—are notoriously not men of resolution. The terms of these teachers of "gymnastics" ought to be very reasonable, both to bring their instruction within the reach of the middle orders, and because—boys being taught in large classes, which will be the best mode of teaching them—lessons may be given at a low rate, and the master still well remunerated. For the practice in itself, we are decidedly inclined to think it beneficial; and we are glad to see the Government institutions setting the example of giving it their support.

GYMNETRUS, a genus of fishes, of the order of thoracici, of which the most remarkable species is, 1. Gymnetrus ascanii, a native of the northern seas, which precedes or accompanies the shoals of herrings, and is known by the title of king of the herrings.

GYMNOPÆDIA, a kind of dance established by Lycurgus, and in use among the Lacedemonians. It was performed during their sacrifices, by young persons, who appeared in a state of nudity, and, while dancing, sung a hymn in honour of Apollo.

GYMNOPODIA. Among the ancients this was a species of shoe, which discovered the naked feet. They were much worn by the Grecian women, who were very fond of them.

GYMNOSOPHISTS, a class of Indian philosophers, of great fame in periods of remote antiquity. They were so denominated from their going barefoot. The name is a Greek compound, signifying a sophist who goes naked. Among their peculiarities, it is said, that, on becoming old and infirm, they threw themselves on a pile of burning wood, to prevent the miseries of an advanced age. Of this sect was Calamus, who burned himself in the presence of Alexander the Great.

GYMNOTUS, or Electrical Eel, is the name of a fish which possesses in itself the power of electricity, communicating it with great effect to all conducting bodies that come within its influence. The length of this fish is from three to four or five feet; the head is short, and sprinkled with perforated dots; the body blackish, with a number of small annular bends or wrinkles; nostrils two on each side, the first large, tubular, and elevated; the other small, and not raised above the skin; the teeth small; tongue broad; and with the palate watery.

GYNÆCEUM. Among the ancients, this was the apartment of the women, in the interior of the house, where they kept themselves retired out of the sight of the men, and were employed in spinning. Under the Roman emperors there was a particular establishment of Gynæcea, being a kind of manufactories chiefly under the management of women, for the making of clothes and furniture for the emperor's household. In imitation of these, many modern manufactories, particularly those of silk, where a number of females are associated, are called Gynæcea.

GYNÆCOCOSMI, Athenian magistrates, in ancient times, whose business it was to regulate the apparel of women, according to the rules of modesty and decency.

GYNÆCOCRACY, a form of government, in which females are eligible to the supreme command. This mode of government is applicable to England and Spain, but the French exult that their monarchy is not gynæcocratic.

GYPSIES, a wandering race of people, against whom there are several statutes, by which they are treated as rogues and vagabonds.

GYPSINE Stone, a name given by some writers to the gypsum or fossil substance, of which the powder called *plaster of Paris*, is made by calcination. In many parts of Arabia there are vast rocks of this stone. It resembles alabaster, but is softer, and more lax in texture.

GYPSINUM Metallum. In the natural history of the ancients, this was a name used for the common *lapis specularis*, of which they frequently made windows, as we do of glass. By some it was called *Cyprinum metallum*, because often found in the island of Cyprus.

GYPSOCHI, a name given to artists who work in plaster.

GYPSUM, *Sulphate of Lime*. Gypsum has probably been formed by the decomposition of iron pyrites, which supplied the sulphuric acid that afterwards united with the subjacent lime. As a confirmation of this, it may be observed, that the marl and sand over gypsum, in many parts of England, contain a large quantity of red oxide of iron. Gypsum is distinguished from lime by its softness; it does not effervesce with any acid, being already saturated with the sulphuric. In some instances native sulphur is found intermixed with gypsum; in these cases, probably the sulphuric acid has been decomposed by the presence of animal or vegetable matter during the decomposition of pyrites. Gypsum has been occasionally discovered in primary and transition mountains: it belongs more peculiarly to secondary stratified rocks, but may be formed in all situations where lime and sulphuric acid exist near to each other. Though gypsum rarely contains shells, bones are sometimes found in it; hence it has been supposed, that sulphuric acid destroyed the traces of organization in the former, which consist of lime and carbonic acid, but acted with less force on bones, which contain phosphoric acid.

GYRATION, Centre of, in Mechanics. When any system of bodies is caused to revolve round a centre, by the action of a force applied at a given distance, which remains unchanged, there will exist some point, in which, if all the matter be collected, the same force applied at the same distance will generate the same angular velocity in the same time, as if the bodies were disposed at their respective distances: this point is called *the centre of Gyration*.

GYRFALCON, in Ornithology, is the name of a large and fierce species of falcon, called in English jerfalcon.

GYRINUS, *Water Flea*, a genus of insects of the order coleoptera. The insects of this genus are found on the surface of waters, on which they run, and describe circles with a great degree of swiftness; when attempted to be taken, they plunge to the bottom, drawing after them a bubble very similar to a globule of quicksilver. Eleven species have been described, of which G. natator only is found in Europe.

GYROVAGI, a name given to a tribe of vagabond monks, who leaving their monasteries, under pretence of piety, wandered about from one religious house to another. The same appellation was also given to priests who left their parishes.

H.

H or *h*, the eighth letter and sixth consonant in our alphabet; though some grammarians will have it to be only an aspiration or breathing, pronounced by a strong expiration of the breath between the lips, closing, as it were, by a gentle motion of the lower jaw to the upper, and the tongue nearly approaching the palate.

H, used as a numeral, denotes 200; and with a dash over it, $\bar{H}$, 200,000.

HABEAS CORPUS, in Law, a writ of various uses, and of different importance. The most efficacious kind in all manner of illegal confinement, is that of *habeas corpus ad subjiciendum*, which is the subject's writ of right, in cases where he is aggrieved by illegal imprisonment, or any unwarrantable exercise of power. By the statute of 31 Charles II. c. 2. emphatically termed the *habeas act*, it is enacted, That on complaint, in writing, by or on behalf of any person committed and charged with any crime, (unless committed for felony or treason expressed in the warrant, or as accessary, or on suspicion of being accessary before the fact to any petit treason or felony plainly expressed in the warrant, or unless he be convicted or charged in execution by legal process,) the lord chancellor, or any other of the twelve judges in vacation, upon viewing a copy of the warrant, or affidavit that the copy is denied, shall (unless the party have neglected for two terms to apply to any court for his enlargement) award an habeas corpus for such prisoner, returnable immediately before himself or any other of the judges, and upon return made, shall discharge the party, if bailable, upon giving security to appear, and answer to the accusation preferred against him, in the proper court of judicature. That such writs shall be indorsed, as granted in pursuance to the act, and signed by the person awarding them. That the writ shall be returned, and the prisoner brought up within a limited time, according to the distance, not exceeding in any case 20 days. That the officers and keepers neglecting to make due returns, or not delivering to the prisoner or his agent, within six hours after demand, a copy of the warrant of commitment, or shifting the custody of a prisoner from one to another, without sufficient reason or authority, (specified in the act,) shall, for the first offence, forfeit £100, and for the second offence £200, to the party aggrieved, and be disabled to hold his office. That no person, once delivered by habeas corpus, shall be recommitted for the same offence, on penalty of £500. That every person committing treason or felony, shall, if he require it, the first week of the next term, or the first day of the sessions of oyer and terminer, be indicted in that term or session, or else be admitted to bail, unless the king's witnesses cannot be produced at that time; and if acquitted, or if not indicted and tried in the second term or session, he shall be discharged from his imprisonment for such imputed offence; but no person, after the assize shall open for the county in which he is detained, shall be removed by habeas corpus till after the assizes are ended, but shall be left to the justice of the judges of assize. That any such prisoner may move for and obtain his habeas corpus, as well out of the Chancery or Exchequer, as out of the King's Bench or Common Pleas; and the lord chancellor, or judges, denying the same on sight of the warrant, on oath that the same is refused, shall forfeit severally to the party aggrieved the sum of £500. That this writ of habeas corpus shall run into the counties palatine, cinque ports, and other privileged places, and the islands of Jersey, Guernsey, &c. That no inhabitants of England (except persons contracting, or convicts praying to be transported, or having committed some capital offence in the place to which they are sent) shall be sent prisoners to Scotland, Ireland, Jersey, Guernsey, or any place beyond the seas.

The writ of habeas corpus issues out of the King's Bench or Common Pleas, not only in term, but in vacation, by a fiat from the chief justice, or any other judge; and runs into all parts of the king's dominions. If it issues in vacation, it is usually returnable before the judge himself who awarded it, and he proceeds by himself thereon, unless the term should intervene, when it may be returned in court.

To obtain this writ, application must be made to the court by motion. This writ may also be obtained to remove every unjust restraint on personal freedom in private life, though imposed by a husband or a father; for when women or infants are brought up by habeas corpus, the court will set them free from an unmerited or unreasonable confinement, and will leave them at liberty to choose where they will go.

The habeas corpus *ad faciendum et recipiendum* issues only in civil cases, and lies where a person is sued, and in gaol, in some inferior jurisdiction, and is willing to have the cause determined in some superior court; in this case the body is to be removed by habeas corpus, but the proceedings must be removed by certiorari.

Habeas corpus *ad respondendum*, is where a man hath a cause of action against one who is confined by the process of some inferior court: in which case, that writ is granted to remove the prisoner to answer this new action in the court above.

Habeas corpus *ad deliberandum et recipiendum*, is a writ which lies to remove a person to the proper place or county where he committed some criminal offence.

Habeas corpus *ad satisfaciendum* lies after a judgment, when the party wishes to bring up a prisoner to charge him in execution in the inferior court.

Habeas corpus upon a *cepi* lies where the party is taken in execution in the court below.

Habeas corpus *ad testificandum* lies to remove a person in confinement, in order to give his testimony in a cause depending.

HABIT, in Philosophy, an aptitude or disposition either of mind or body, acquired by a frequent repetition of the same act.

HACKLE, an implement used in dressing flax.

HÆMANTHUS, in Botany, blood flower.

HÆMATOPUS, *the Oyster Catcher*, a genus of birds of the order grallæ, sixteen inches in length, and about the size of a crow, is to be met with on almost every sea-shore. The general food of these birds consists of shell-fish; they force the limpet from the rock, and on perceiving the slightest aperture of its shells by an oyster, they insert their bills in it with admirable dexterity, and tear the tenant from his mansion.

HÆMATOXYLUM, logwood.

HÆMATITES, blood-stone.

HÆMORRHAGE, a flux of blood from any part of the body.

HÆMORRHAGY, in Medicine, a flux of blood.

HAGIOGRAPHA, (Αγιος, *Holy*.) The Jews divide the Old Testament into three parts. 1. The Law, which comprehends the five books of Moses; 2. The Prophets; and, 3. The Writings, termed by them *Cetubim*, and by the Greeks *Hagiographa*, whence the word has been introduced into the English language. The *Cetubim* comprehended the books of Psalms, Proverbs, Job, Daniel, Ezra, Nehemiah, Chronicles, Ruth, Lamentations, Ecclesiastes, and Esther. The *Hagiographa* were distinguished from the prophecies because the matter contained in them was not received by the way of prophecy, but simply by direction of the Spirit.

HAIL, or HAILSTONES, in Meteorology, an aqueous concretion of irregular form, descending from the atmosphere like frozen rain, a scourge that devastates and even annihilates in an hour the richest crops. *Hailstones* are seldom spherical, as their size adds to their irregularity, and their cavities and angles indicate successive amalgamations. As hail falls mostly in summer, this would be a matter of surprise, did we not know the cause. The first drops, formed in the high regions, by the influence of greater cold, are almost immediately frozen. In falling, they traverse humid layers, whose vapours, suddenly condensed by the contact of a frozen body, cluster round it in concentric coats, and form a mass, increasing with the interval passed.

HAILING, the salutation or accosting of a ship at a distance, which is usually performed with a speaking trumpet; the first expression is 'hoa, the ship ahoay,' to which she answers 'holloa;' then follow the requisite questions and replies, &c.

HAIR, slender filaments issuing out of the pores of the skins of animals, and serving most of them as a covering, but some animals in lieu of hair are covered with feathers, wool, and scales. All hair appears round, yet the microscope discovers square, triangular, and hexagonal hairs. And though hair usually appears on the external surface of the bodies of animals, there are many testimonies corroborating the fact, that, the tongue, the heart, the kidneys, &c. have in different individuals been covered with hair.

Human hair makes a very considerable article in commerce, especially since perukes have been so generally used. The hair of the growth of the northern countries is valued much beyond that of the more southern ones. The merit of good hair consists in its being well fed, and neither too coarse nor too slender. Its length should be about twenty-five inches. Hair is bleached on the grass like linen, after first washing it out in a bleaching water, and may be dyed of any colour. When it does not curl or buckle naturally, it is brought to it by art, first boiling, and then baking it.

Hair is also used in various other arts and manufactures; and when spread and left to putrify on corn lands, proves good manure. By an experiment of Berthollet's, 1152 parts of hair yielded carbonate of ammonia, 90; water, 179; oil, 288; gases, 271; coal, 324 parts.

From numerous experiments, M. Vauquelin infers, that black hair is formed of nine different substances, namely, 1. An animal matter, which constitutes the greater part. 2. A white concrete oil in small quantity. 3. Another oil of a grayish green colour, more abundant than the former. 4. Iron, the state of which in the hair is uncertain. 5. A few particles of oxide of manganese. 6. Phosphate of lime. 7. Carbonate of lime in very small quantity. 8. Silex, in a conspicuous quantity. 9. Lastly, a considerable quantity of sulphur. The same experiments shew, that red hair differs from black only in containing a red oil instead of a blackish green oil; and that white hair differs from both these only in the oil being nearly colourless, and in containing phosphate of magnesia, which is not found in them.

Hair is usually distinguished into various kinds: the stiffest and strongest is called bristles, such as that on the backs of swine. When remarkably soft and pliable, it is denominated wool, as that on sheep, and the finest of all is called down.

HAIR, or *Down of Plants*, a general term, expressive of all the hairy and glandular appearances on the surface of plants, to which they are supposed by naturalists to serve the double purpose of defensive weapons and vessels of secretion.

HAIR'S *Breadth*, a measure of length, being the 48th part of an inch.

HAKE, in Ichthyology, the English name of the Gadus, with two fins on the back, and the under jaw longest. It grows above two feet in length, but is the slenderest of all the gadi. *See* GADUS, *the Cod*, p. 346.

HALBARD, or HALBERT, in the art of war, a well-known weapon carried by the sergeants of foot, is a sort of spear, the shaft of which is about six feet long. Its head is armed with a steel point, edged on both sides, but besides this sharp point, which is in a line with the shaft, there is a cross piece of steel, flat and pointed at both ends, but generally with a cutting-edge at one extremity, and a bent sharp point at the other, so that it serves equally to cut down or push withal.

HALE, in the sea language, signifies pull.

HALF MARK, a noble, or six shillings and eightpence.

HALF *Moon*, in Fortification, an outwork composed of two faces, forming a salient angle, whose gorge is in form of a half-moon.

HALF-PIKE, a defensive weapon, composed of an iron spike, fixed on an ashen staff; its use is to repel the assault of boarders in a manner similar to the defence of the charged bayonet among infantry; hence, it is frequently termed a *Boarding-Pike*; it takes the epithet of half, from its having a much shorter staff than the whole pike.

HALIOTIS, in Natural History, the ear-shell. Animal a limax; shell univalve, dilated, ear-shaped, with a longitudinal row of orifices along the surface; spire lateral, and almost concealed. There are nineteen species.

HALLEY, EDMOND, an eminent English mathematician and astronomer, was born in London, October 29, 1656; to whom the sciences are much indebted for many important improvements and discoveries.

HALL, in Architecture, a large room at the entrance of a fine house or palace. The hall is properly the finest as well as the first of a suite of apartments. In halls, or saloons, ministers of state despatch business, give audience, &c. The length of a hall should be at least twice and one-fourth its breadth, and in height two-thirds the breadth.

HALLIARDS, the ropes or tackles usually employed to hoist or lower any sail upon its respective masts or stay, except the cross-jack and sprit-sail-yard, which are always flung; but in small craft the sprit-sail-yard has halliards.

HALO, is an extensive luminous ring, including a circular area, in the centre of which the sun or moon appears; whose light, passing through an intervening cloud, gives rise to the phenomenon. Those about the moon are most common. The following enumeration will perhaps be more acceptable to our readers than if we treated of lunar haloes only.

Corona. When the sun or moon is seen through a thin cloud, a portion of the cloud, round the sun or moon, appears lighter than the rest; and this luminous disc is called a *corona.* They are of various sizes, but they seldom exceed 10° in diameter: they are generally faintly coloured at their edges. Frequently when a halo encircles the moon, a corona surrounds it.

Parhelia, or mock suns, vary considerably in general appearance: sometimes the sun is encircled by a large halo, in the circumference of which the mock suns usually appear, which have often small haloes round them.

The *paraselene*, the *parhelion*, and the several kinds of *halo* and *corona*, have all been considered as resulting from the intervention of clouds between the spectator and the sun or moon, through which the light passes. But we must be more philosophical. It is well known that the immediate effect of the different refrangibility of light, in producing colours, is sometimes spontaneously exhibited in the atmospherical phenomena of haloes, parhelia, and paraselenæ; the edge nearest the luminary being generally reddish, and the remoter parts green and blue, without any well marked limitation of the different tints. These appearances must therefore be referred to the refraction of the prismatic crystals of snow, floating in, and descending through the atmosphere, in all possible, but especially vertical or horizontal positions, and sometimes, perhaps, from their connexion with other crystals, making angles of 60° with these positions.

At Dantzic, in 1660, Hevelius saw two fine paraselenæ: the first, March 30. At about one o'clock in the morning, the moon A was surrounded by an entire whitish circle, B C D E, 45° in diameter, in which were two mock-moons at B D, one at each side of the moon, of various colours, and emitting long whitish beams. The tail of that on the left, extended towards the thigh of Serpentarius; of that on the right, towards Jupiter ♃. Afterwards, at two o'clock, a larger circle, of 90° diameter, surrounded the less one, and reached to the horizon. The tops of both these circles were touched by coloured arches, resembling inverted rainbows. The interior arch at C was a portion of a larger circle of 90°; and the superior F a portion of a lesser, of 45°. This extraordinary appearance continued three

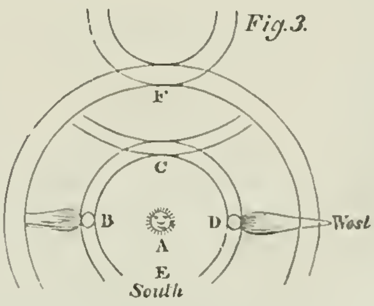


Fig. 3.

hours; the outward great circle vanished first; then the larger inverted arch at C, soon afterwards the lesser; and, last of all, the inner circle B C D E.

The second was seen on December 17, and on the first day after the full moon, at 30′ past six in the morning, the moon being 12° high, she appeared with three mock-moons about her. The air being very clear, the moon first appeared, surrounded with a double corona, near her body, tinged with very bright and beautiful colours. On each side were two arches, of a circle about 45° diameter, extending down to the horizon, and coloured like the rainbow; in which were two mock-moons, with long white tails; that on the left was near Procyon, with a shorter tail; the other was longer. In the upper part, where these collateral arches concurred, was another arch, inverted, and variously coloured; in the middle of which was a third mock-moon, duller than the others. A very extraordinary part of this appearance was a large, white, rectangular cross, through the moon's disk, whose lower part reached down to the horizon, but on each side did not quite touch the corona. It was so very bright and strong, that it shone distinctly and clearly till sun-rise; but the mock-moons disappeared a little before.

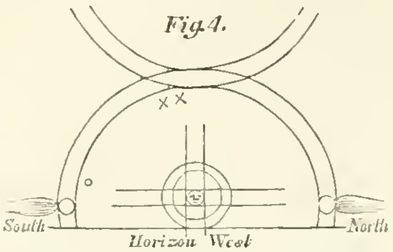
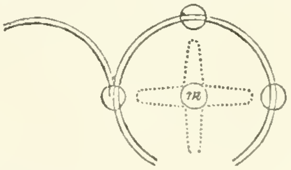


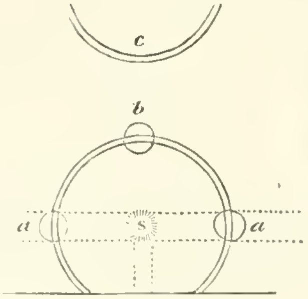
Fig. 4.

During the time that the Hecla and Griper were frozen up in the North Polar ocean, several interesting meteorological phenomena were witnessed. At ten A. M. Jan. 1st, 1820, a halo, whose radius was 22° 30′, with three paraselenæ, which were very luminous, but not tinged with the prismatic colours, was seen about the moon; and on the following day the same phenomenon occurred, with the addition of a vertical stripe of white light proceeding from the upper and lower limbs of the moon, and forming, with a part of the horizontal circle seen before, the appearance of a cross, as shewn in the accompanying diagram.



There was also at times an arc of another circle touching the halo, which sometimes reached almost to the zenith, and changed the intensity of its light very frequently, not unlike the aurora borealis.

On the 4th of March also, at half-past eleven A. M. a halo appeared round the sun, at the distance of 22° 17′ from it, consisting of a circle nearly complete, and strongly prismatic. Three parhelia or mock-suns were distinctly seen upon this circle; the first being directly over the sun, and one on each side of it, and its own altitude, as in the preceding diagram. The prismatic tints were much more brilliant in the parhelia than in any other part of the circle; but red, yellow, and blue, were the colours which could be traced, the first of these being invariably next the sun, in all the phenomena of this kind that came under observation. From the sun itself several pencils of rays of white light, continuous but not very brilliant, extended in various directions beyond the halo, and these rays were brighter after they had passed through the circle, than they were in the part within it. This phenomenon continued nearly two hours. The aurora borealis was seen faintly near the SSW horizon, for three or four hours before midnight.



On the 8th of the same month, from ten to eleven A. M, a halo and three parhelia appeared about the sun, in every respect similar to those seen and described on the 4th. About one o'clock P. M., there being a fresh breeze from the northward, with some snow-drift, the parhelia re-appeared, being much more bright and prismatic than in the forenoon, and accompanied by the usual halo, which was nearly complete, and whose radius was measured 22° 30′. The parhelia *a, a*, in the foregoing figure, on each side of the sun, were at times so bright as to be painful to the eye in looking steadfastly at them. When they were brightest, the light was nearly white.

HAMMER, a well-known tool used by mechanics, of which there are various sorts, but they all consist of an iron head fixed crosswise to a handle of wood. Among blacksmiths, there are the hand-hammer, the uphand sledge, the *about* sledge, which is swung over head with both arms, &c.

HAMMER, A POWERFUL FORGE. This hammer is intended to be wrought by one or more men, as occasion requires. It is well adapted to the forging of bricklayers' trowels, rounding of ships' bolts, beating gold or tinfoil, planishing brass, copper, or, in short, for any work in which a large hammer is required upon a simple principle. The weight of the hammer is seventy pounds, yet one man will work it with the greatest ease and accuracy, and it performs the work of two or three men. The steel forged with it is kept in excellent temper; for as it does not require to be so often heated as in the common way of working, it preserves a high degree of elasticity and firmness.

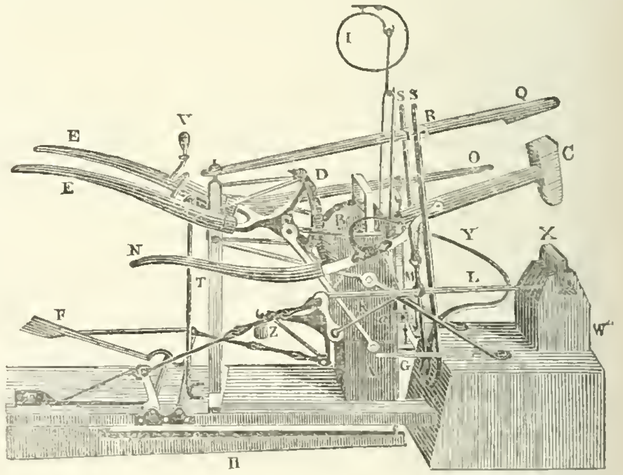
This forge hammer is represented in the following engraving.

Fig. 1, A, a block of oak, in which the hammer acts.

B, the wheel or nave, in which the hammer-handle C is fixed; also the chains which give motion to the hammer by the quadrant D.

EE, are the two levers which work the quadrant D.

FF, are the two pedals on which the man who works the machine treads alternately, holding the levers EE in his hands. When he treads on the right pedal F, he lifts the hand-levers EE, which motion raises the hammer C; when he treads on the left pedal, he presses on the same levers, which motion lets fall the hammer.



G, is a rack which moves perpendicularly, by the action of a strong wooden spring H, placed in a trough underneath the centre of the machine; the rack is kept close to the quadrant K, by a bridge *a* containing a small friction roller.

I, an additional steel spring, fastened to the ceiling over the machine, in order to assist the wooden spring H, when fewer hands are at work.

K, is the quadrant contained in the centre of the oak block A, under the nave B, which assists in raising or depressing the hammer, by the alternate actions of the pedals F F.

L, is a lever fixed on the axis of the quadrant K, which, at the time it depresses the rack G, pulls upon the hammer-handle C, by the chain M, which adds to the power of the blow.

N O, are the two side levers, to be worked by two men, when more power is required.

P P, are other two pedals, on which a man treads alternately, to give motion to the hammer, having an upright rod or chain to each pedal; one rod is connected from the right pedal P, to the lever O, which raises the hammer; the other rod, from the left pedal P, is connected to the handle of the hammer C; when the man treads upon the left pedal P, he acts upon the hammer C, and, by lifting the lever O with both hands at the same time, adds double power to the blow.

Q, is a wooden spring or stop, which prevents the hammer from rising too high, and accelerates the fall.

R, is a bridle, which supports the wooden spring Q.

S S, are two iron standards, with holes in each, to raise or depress the said spring.

T, is a wooden standard, to support one end of the wooden spring Q.

V, is a tempered steel spring standard, to support the hammer while out of action; it also gives ease to the springs, and prevents the heat of the anvil from softening the face of the hammer.

U, is a solid block of oak, on which the anvil stands.

W, the anvil, with a hollow dove-tail on the top, for the reception of different faces, as the various kinds of work may require.

X, a steel face, dove-tailed in the anvil.

Y, a steel spring, which lies beneath the hammer-handle, but only touches it when the hammer falls; this spring, when the heated metal is laid upon the anvil, and in a soft state, prevents the hammer from falling upon it with its full force. It gives a recoil to the hammer, and permits the workman to modify or shorten the stroke of the hammer with quickness, ease, and regularity.

Z, a weight hung on the arm of the quadrant K, in order to counteract the power of the hammer occasionally, when light work is to be forged. The hammer head with the face let into it may be taken out and changed, to suit different kinds of work.

HAMMOCK, a piece of hempen cloth, six feet long and three feet wide, gathered together at the two ends by means of a clue, and hung horizontally under the deck, forming a receptacle for a bed. There are usually from fourteen to twenty inches in breadth allowed between decks for every hammock in a ship of war; this space, however, must, in some measure, depend on the number of the crew, &c. in proportion to the room of the vessel. In preparing for battle, the hammocks, together with their contents, are all firmly corded, taken upon deck, and fixed in various nettings, so as to form a barricade against small shot. *See* the article Engagement.

HANAPER, an office in Chancery, under the direction of a master, whose deputy and clerks answer, in some measure, to the *fiscal* among the Romans. The *clerk of the hanaper* receives all fines due to the king for seals of charters, patents, commissions, and writs. He attends also the keeper of the seal daily, in term, and at all times of sealing, and takes into his custody all sealed charters, patents, &c.

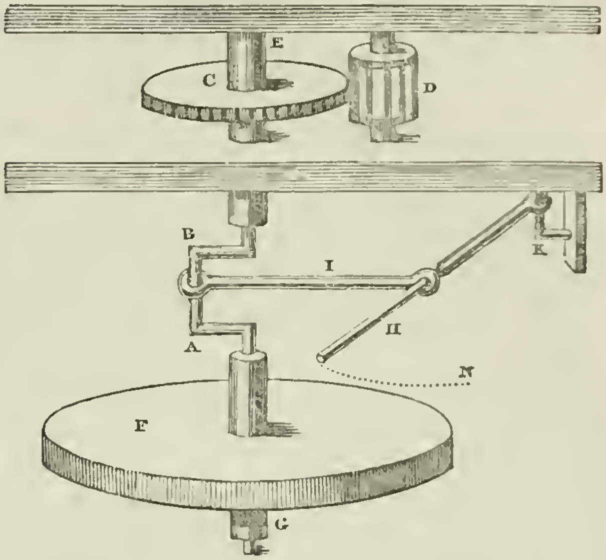
HANCHES, in Architecture, are intermediate parts of arches between the crown and the spring at the bottom, being probably about one-third of the arch, and placed nearer the bottom than the top. Hanches are likewise called *spandrells*.

HAND, a measure of four inches, or of the clenched fist. In Painting and Sculpture, it signifies also the style of the artist. —*Hands* are borne in coats of armour, right and left, expanded or open; and a bloody hand in the centre of an escutcheon, is the badge of a baronet of Great Britain.

Handbreadth, a measure of three inches.

Hand *Cuffs*, an instrument formed of two circular pieces of iron, each fixed on a hinge on the ends of a very short iron bar, which being locked over the wrists of a malefactor, prevents his using his hands.

HANDMILLS, are commonly used for some culinary purposes, as the grinding of coffee, pepper, and the like. Sometimes handmills of larger size are used to grind malt, wheat, &c. and in such cases the hand is generally applied to a winch handle; but the effort of a man may be applied to a lever moving to and fro horizontally, nearly as in the action of rowing; and this is a very advantageous method of applying human strength, the effort being greatly assisted by the heaviness of the man in leaning back: we shall therefore give a brief description of this kind of mill, which is represented in the following figure. The vertical shaft E G carries a toothed wheel C, and a solid wheel F; the latter being intended to operate as a regulating fly. Upon the crank A B hangs one end of an iron bar I, the other end of which hangs upon the lever H K; the motion being pretty free at both ends of this bar I. One end of the lever H K hangs upon the fixed hook K, about which as a centre of motion it turns. Then, while a man, by pulling at the lever H K, moves the extremity H from H to N, the bar I acting upon the crank A B, gives to the wheels C and F half a rotation; and the momentum they have acquired will carry them on, the man at the lever suffering it to turn back from N to H, while the other half of the rotation of the wheels is completed. In like manner another sufficient pull at the lever H K gives another rotation to the wheel C, and so on, at pleasure. The wheel C turns by its teeth the trundle D, the spindle of which carries the upper millstone.



In this mill, the nearer the end of the bar I upon the lever H K is to the fixed hook K, the easier, *cæteris paribus*, will the man work the mill. If the number of teeth in the wheel C be six times the number of cogs in the trundle D, then the labourer, by making 10 pulls at the lever H in a minute, will give 60 revolutions to the upper millstone in the same space of time.

HAND Railing. Hand-railing is the art of forming hand-rails by moulds according to geometrical rules. The principles upon which this art depends, are that of cutting a right prism through any three given points in space, and that of forming a development of any portion of the surface of the prism.

In order to illustrate this, let the interior surface of the surrounding wall be that of an entire cylinder, and let the breadth of the steps be divided into the frustums of equal and similar sectors, and let the heights be all equal, as is universally the case; then, if an interior cylindric surface be erected concentric with the wall, and the ends of the steps or surfaces on which we tread, and the planes of the risers tending to the axis be supposed to meet the interior cylindric surface, it is evident that if the portion of the intercepted surface contained between the indented line formed by the ends of the steps, and the circumferent line at the base, be developed or stretched out, all the points of the indented line formed by the outward or salient angles, will be in the same straight line, and all the points formed by the inward or re-entrant angles will be in another straight line. It is also evident, that this will not only be the case with cylinders, but with cylindroids, and every other description of prism; that is, the points of the development of the indented line will always have such a position, that two straight lines parallel to each other may be drawn through the whole number of points.

The points of concourse of the salient angles are called the nosings of the steps.

The line drawn through all the nosings of the steps, is called the line of the nosings.

Now let the portion of the cylinder before uncovered, be again enveloped, the development in this state becomes an envelope, and the line of nosings becomes an uniform helix, which would be the form of the rail for such a stair.

In this case it would be easy to execute the rail to any length we please, in equal portions succeeding each other; for as the curvature of the helical line is every where the same, the same moulds which are used in the formation of one piece, would serve for every succeeding piece.

The steps placed around the circular part are termed winders; in these the risers tend to the axis of the cylinder.

Steps which have their treads the same breadth, are termed flyers; in these the risers are all parallel.

Very few staircases are however entirely circular, but those of the semi-circular form, with winders in the semi-circle, and flyers below and above, are very numerous; in such the line of nosings would be crooked, and would form an angle at the junction of the flyers and the winders, and that round the semi-circle would be a helix, consisting of half a revolution.

In the development of the steps, the line of nosings would consist of three straight lines, the two straight lines through the nosings of the flyers would be parallel to each other, and each extremity of the middle one would join one extremity of each of the other two; the angles are commonly taken away by introducing a curve in their places.

A hand-rail, however, is not a mere helical line, but a solid, which may be contained between two concentric cylindric surfaces, or concentric prismatic surfaces. The principles are the same, whatever be the form of the plan. A solid erected upon any plan, is called a prism; a cylinder is therefore a round prism, and a cylindroid an elliptic prism. A hand-rail may stand upon a circular base, or partly circular and partly straight, or upon an entire elliptic base. In the construction of hand-rails, all prisms are excluded which consist of plain surfaces, or, which is the same thing, where the sides of the plan consist entirely of straight lines, as in such cases, the rails themselves are either straight, or partly curved and partly straight from the top and lower sides only, the sides being in vertical planes.

We shall therefore confine ourselves to prisms that stand upon a circular base, or upon an elliptic base, or upon a base that is partly circular and partly straight, or, lastly, upon a base that is partly elliptical and partly straight. These two last may be said to have compounded bases or plans, and the former two simple bases or plans; let us call such a prism a curved prism.

The plan of any curved prism is understood to be of the same breadth, and consequently the solid erected thereon will be every where of the same thickness. The prism may therefore be a hollow cylinder, or a hollow cylindroid, or a concave body partly cylindric and partly straight; the latter may be open on one side, and may have the four planes which join the curved surfaces parallel to each other, and tangent to each of the cylindric surfaces.

Let us therefore suppose such a prism as that last mentioned, and let us suppose it to be cut entirely through its vertical surfaces, in such a manner that any point in the surface of division may coincide with a straight line every where perpendicular to the external prismatic surface, then, every such line will be parallel to the plane of its base, and those lines in the cylindrical part of the prism will tend to the axis. Now it is evident, that the cut or dividing surface will not be a plane, but will wind or twist between the cylindric surfaces. It is also evident, that the cut may pass through a line drawn in any manner we please, in one of the prismatic surfaces; or, that the development of this line may have any degree of curvature in the whole length, or in any portion of the length, or may even be a straight line. One of those being supposed to be the case, let the upper part of the prism be taken away, then the upper surface of its remaining part will be brought to view; let a line be drawn on the exterior surface, parallel to the arris, and another on the concave side, parallel to its arris; and let another cut or dividing surface be made to pass through the two lines thus drawn, and let the upper part be removed by this division, then the part thus removed will form a solid helix or kind of half screw, which may be either uniform in its upper and lower surfaces, or have any degree of curvature in any part that may be required, according to the development before mentioned. This is the form of the rail for such a stair, but to form the solid helix, without cutting it, from a hollow curved prism, is the thing required to be done in hand-railing.

Now, seeing that two of its sides are actually cylindrical, and would be vertical if placed in position; and that the other two winding surfaces may be formed to any development we please; let us therefore take any determinate portion of the helical solid, as a quarter of a revolution, or perhaps something more, as occasion may require, and endeavour to form such a portion or wreath out of a thin plank, instead of cutting it from a solid curved prism. Before this can be done, it is necessary to understand the principle of cutting a prism through any three fixed points in space, by a plane passing through these points; the points may be in the surface of the prism itself, and may be either all in the concave side, or all in the convex side; or partly in the concave side, and partly in the convex side:—That such a supposition is possible will readily appear, since any three points are always in the same plane; and, therefore, the plane may cut the prism through any three given points.

The three points through which the section is cut, are said to be given, when the seats are given on the plane of the base of the prism, which plane is understood to be at right angles to the axis of the prism, and when the distance or heights from the seats to the points themselves are given.

It is always to be understood, that the three seats are not in a straight line, and consequently the three points themselves not in a straight line.

The seat of a point in space on any plane, is that point in the plane, where a perpendicular drawn through the point in space, cuts the plane.

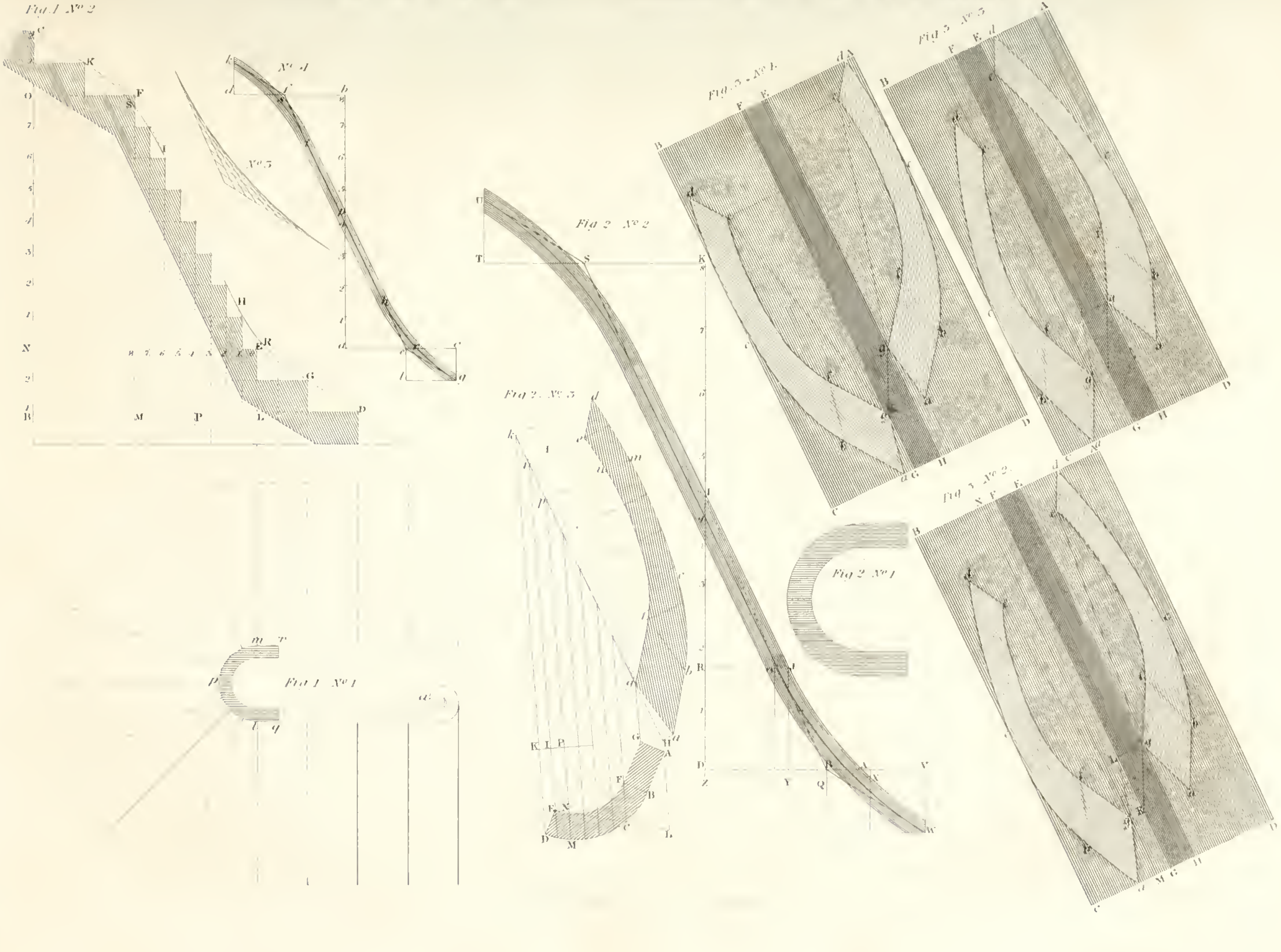
This being established, we shall proceed to shew the best means of applying these principles to hand-railing.

In the helical solid, the winding surface connecting the two prismatic surfaces, was defined to be of such a property, as to coincide with a straight line perpendicular to the exterior prismatic surface, and consequently, if the axis of the curved prism be perpendicular to the horizon, every such line will be parallel to the base; now, let the seats of three such lines be given on the plan, *viz.* let each extreme boundary be one, and let another be taken in the convex side, passing through the point which would give the middle of the development of the said side of the plan; the three seats would be terminated by the convex and concave sides of the plan, and will always be perpendicular to the convex side, and equal in length to each other. Let us call the three level lines, of which their seats are given, the lines of support; let a plane be laid on the three lines of support, the plane will either rest upon three points or upon one of the said lines and two points; it is evident that the points which come in contact with the plane, will be at one extremity of each line of support; let each of these points which come in contact with the plane thus posited, be called a resting point. The three resting points are the three points in space, through which the plane is supposed to pass, that cuts the curved prism.

Now, because that each line of support has two extremities, there will be six extreme points in all, but as only three can be resting points, unless the plane coincides with one of the lines of support, it will be proper to shew, which three of the six are the resting points. Let the plane, thus laid upon some three extremities of the lines of support, be continued to intersect the base of the curved prism, then the nearest extremity of the seat of any line of support to the intersecting line, is the seat of the resting point of that line.

For this purpose let a development of the convex side of the rail be made according to the plan and rise of the steps.

PETER NICHOLSON'S MODE OF SQUARING HAND RAILS TO STAIRS.



The part of this development that is made to bend round the convex or concave cylindric surface of the helical portion or wreath, is called a falling mould, which is supposed to be brought to an equal breadth throughout its length. Only one falling mould is used in the construction of hand-rails. Let, therefore, the falling mould for the convex side be constructed, and let two straight lines be drawn from the ends of the upper edge of that part of the falling mould corresponding to the ends of the wreath, perpendicular to the base of the whole development; also, let another intermediate line be drawn parallel to the other two, so as to bisect the part of the base intercepted by the said two parallels: the three parallels will thus give the heights of the three resting points, the shortest height is at one extreme, and the longest at the other. Suppose now, the shortest of these three heights taken from each of the three, and the remainders taken at heights, instead of the whole, then the height of the first resting point will be nothing, and will therefore coincide with its seat; then, if the middle height be less than half the length of the remaining height, the seats of the resting points will be the first and second extremities of the first and second lines of support taken on the convex side, and the extremity of the third on the concave side. The first resting point is a point in the intersection of the plane of the base with the inclined plane.

The process is now completely reduced to that of finding the section of a prism through three given points, which suppose to be done, and the plane of section will touch the supposed wreath, at the resting points of each line of support, without cutting the wreath of any such line—then, the three lines of support will be on the same side of the plane, *viz.* on the under side. Let us suppose now, another section taken below, and parallel to the former, so that the wreath may be just contained between these parallel sections, or planes; the distance between the two sections will represent the thickness of the plank.

The section of the prism through its vertical surfaces, is called the rake, or the rake of the plan: and a mould being cut to the rake, is called the face mould.

The above are the general principles; the particulars will be best understood by the explanations which accompany the diagrams in the Plate, and the following wood engravings.

Let fig. 1, No. 1, in the Plate, be the plan of a geometrical stair, with eight winders in the semi-circle, and flyers above and below; the first or lower steps being denoted by the scroll *a*; let *q l p m r* be the plan of the part of the rail that is to be formed in two wreaths; and *q l* and *m r* straight parts; in order for the better securing of the wreaths to the straight parts opposite the flyers.

Let fig. 1, No. 2, be the development of twelve steps, including that of eight winders, two flyers below and two above; D B being the base, and B C the height. In the base D B, No. 2, L P M is the development of *l p m*, No. 1, and L D, M B, the breadths of two steps corresponding to the plan. In the height B C, N O is the height of the winders, and N B, O C, each the height of two steps answering to the flyers at each end. D E F C, is the line of nosings; the parts D E, F C, of the flyers, being parallel to each other, and joined by the part E F, the development of the winders; G R H, and I S K are curves tanged by the straight lines E D, E F, and F E, F C, at the points G, H, I, K, or rounded off, as shewn at No. 3, on a longer scale, so as to form an agreeable curved line without angles.

The line G R H I S K may be called the line of the rail, being of the same form as the line bisecting the breadth of the development of the rail, for the one may be supposed to be every where of the same height from that of the other, and therefore, the line G R H I S K, may be conceived to be the development of the rail.

No. 3 shews the manner of drawing the tanged curves G R H, and I S K; No. 2 the upper one I S K, being the same as the lower one G R H, but inverted.

No. 2 shews more lines than are wanted in practice, in order to shew the connexion between the development of the steps, and the development of the line of the rail. But, as the development of the line of the rail is all that is wanted, make *a b*, No 4, equal to the height of the winders, draw *a c* and *d b*, at right angles each with *a b*; make *a e* and *b f* each equal to the development of *l p* or *p m*, No. 1; make *e c*, and *f d*, the breadth of a step; draw *c g* and *d k* parallel to *a b*; make *c g* and *d k* each equal to the height of a step; join *e g f k* and *e f*; make *e h* equal to *e g*, and *f i* equal to *f k*, and draw the tanged curves *g r h* and *i s k* as before; then *g r h i s k*, will be the line of the rail, as in No. 2; for *e f* will be obtained, equal to E F, No. 2; and *e l g* will be the section of a flyer at the lower end, and *f d k* the section of a flyer at the upper end. The breadth of the falling mould, in common cases, is about two inches, therefore, two lines being drawn parallel to the line of the rail, each at an inch distance from it, gives the complete falling mould for both wreaths. The two parts of the falling mould, as divided by *a b*, are equal and similar to each other, and would therefore coincide if applied together.

Let fig. 2, No. 1, be an enlarged plan of the rail, of double dimensions to No. 1, fig. 1, in order that the moulds may be more exactly obtained, and the construction more clearly seen. Let A B C D E F G, fig. 2, No. 3, be the plan of the part of the wreath to be formed, A G being the seat of the line of support at the lowest part, and D E that at the highest part: then A is the seat of the resting point of the lowest end, and E that at the highest end. Take the point C, between A and D, so that C, in the development of the line A B C D, may divide the said development into two equal parts.

Let A B C D, fig. 2, No. 2, be the development of the curve A B C D, No. 3; the parts A B, B C, C D, being the respective developments of A B, B C, C D, No. 3. In No. 2, draw D K perpendicular to D B; and make D K equal to the height of eight steps; draw K S parallel and equal to D B; join B S; produce K S to T, and D B to V; make S T and B V each equal to the breadth of a step; draw T U and V W parallel to D K; make T U and V W equal to the height of a step; join W B, B S, S U: then W B S U is the line of nosings. The whole is completed as in No. 3, fig. 1. Draw A X parallel to K D, cutting the upper side of the falling mould at X; draw X Z parallel to A D; produce K D to Z, and let K D cut the top of the rail at I; through C draw Y J, parallel to D K, cutting the top of the rail at J, and X Z at Y; then Y J and Z I, respectively, are the height of the resting points, whose seats are C and E, No. 3. In No. 2, draw J R parallel to B D, cutting D K at R. In No. 3, join the seats E and C of the resting points, and produce E C to L. In J R, No. 2, find the point O, by making R O equal to E C, No. 3; join I O, and produce I O to meet X Z at Q. In No. 3, make E L equal to Z Q, No. 2, and join A L; through G draw H K, perpendicular to A L, and produce L A to H; through E draw E *i* parallel to L H, cutting H K at I; make I *i* equal to Z I, No. 2, and join H *i*, and produce H *i* to *k*. To find any point in the curve of the section, take any point M in the boundary of the plan, and draw M *p* parallel to E *i*, cutting H *i* at *p* and H I at P; draw *p m* at right angles to H *i*, and make *p m* equal to P M, and *m* is a point in the boundary of the rake. In like manner, let M P cut the concave side of the plan at N; in *p m* take *p n* equal to P N, and *n* is a point in the concave side. A sufficient number of points being thus found, draw a mixed line, *a b c d e f g*, through the whole, and *a b c d e f g* is the figure of the rake. For greater accuracy and despatch, it will be necessary to find a point in the rake corresponding to the extremity of every straight line in the plan, as shewn by small letters of the same names as the capitals on the plan. The part A B F G being a parallelogram on the plan; the corresponding part *a b f g*, on the section, is also a parallelogram; in this case it will be only necessary to find the points *a*, *g*, *f*. Join *a g* and *g f*; draw *a b* parallel to *g f*, and *f b* parallel to *g a*, and the point *b* gives the commencement of the convex curve *b c d*, and the point *f* that of the concave curve. It remains to be shewn that H L, No. 3, is the intersection of the plane on which the section of the prism is formed; for the point A is not only the seat of the lowest resting point, but the resting point itself. A is therefore the point in the intersection of the cutting plane. In No. 2, draw O △ parallel to K Z, cutting B Z at △; conceive the triangle I Q Z to be removed to No. 3, so that the point Z may be upon E; and because R O △ Z is a parallelogram, △ Z is equal to R O, and R O is equal to E C by construction; therefore the point △ will fall upon C: and by construction, the point Q will fall upon L. Conceive the triangle, with its base, thus coincident with L E, to be raised perpendicularly to the plan; I will be the resting point over E, and O the resting point over C; therefore the points I and E will be in the plane of section, and consequently be the straight line I O Q; but the point Q, now supposed to be coincident with L, is common to the plane of the base; and the plane of section, Q, is therefore a point in the intersection of the cutting plane and the base. The point A has likewise been shewn to be a point in the intersection; therefore the straight line H L, passing through the points A and L, is the intersection of the cutting plane with the plane of the base. The point L, No. 3, will be obtained also by a fourth proportional to I R, I Z, R O, or Z △, No. 1, setting it from E to L.

A mould being cut to the form of the section, as here obtained, is called by workmen, the *face mould*, which we shall suppose now to be made.

To find the Thickness of the Plank, out of which the Wreath is to be cut.—Let Z I, No. 2, cut the under edge of the falling mould at ε, transfer Z ε upon K k, No. 3, from K to δ; then the nearest distance between the point δ and the straight line H k, is the thickness of the stuff at the upper joint.

The wreath, when formed into two prismatic surfaces, and into two winding surfaces, is said to be squared. This formation is all that is required from geometrical principles. Then, supposing the wreath set in its proper position, every section made by a vertical plane, perpendicular to the convex side of the plan, will be a quadrilateral with its two vertical sides parallel, and at right angles to the upper side, and at oblique angles to the lower side. This arises from the top being so formed as to coincide in every part with the line perpendicular to the prismatic surface as defined, and the lower winding surface by gauging upon each cylindrical surface from the top.

To draw the Rake on the Slides of the Plank, in order to plumb the two Sides of the Wreath.—Let A B C D, fig. 3, No. 1, be a development of three sides of plank; let A E, H D, be the top; E F, G H, the edge; in breadth equal to the thickness of the stuff obtained from No. 3, and F B, C G, the under sides; let the lines E H and F G be parallel to k H, fig. 2, No. 3, in order to be more easily comprehended, (as otherwise, it is not necessary;) let $a\ b\ c\ d\ e\ f$, on the top of the plank, be the rake formed by the face-mould, the point g being in the line H E, and the line $g\ e$, making the same angle with g E as the line $g\ e$, fig. 2, No. 3, makes with $g\ k$, draw g K, making the angle H g K equal to the angle H k K, or H i I, or H p P, fig. 2, No. 3, cutting the arris, fig. 3, No. 1. G F, at K, then the same mould being drawn on the under side, with the point g at K, and the chord $e\ g$ making the same angle with K F, that $e\ g$, on the upper side, makes with g E, or the distance of the point e from G F, on the lower side, equal to the distance of the point e from H E, on the upper side. Let us now suppose lines drawn in the above manner upon the three corresponding surfaces of the plank to that of the figure, and let the plank be cut out with a bow saw. In the act of cutting, the kerf must be kept close to the corresponding lines of each rake, and the line of the teeth of the saw parallel to g K, and when the piece of the wreath is entirely divested of the superfluous wood, the sides thus formed will be plumbed.

To draw the Rake upon the Plank in every Position to the adjoining arris of the Edge.—Let fig. 3, No. 2, be a development of the plank as before, the same letters referring to the same parts. Let $a\ b\ c\ d\ e\ f\ g$ be the rake drawn by the face-mould, the point g being in the arris H E, and the chord $g\ e$ forming any given angle with the arris H E, less than that formed in No. 1, fig. 3, by the chord $g\ e$, and the arris H E; find g as before from No. 3. In No. 3, draw g I, making the same angle with the pitch line $g\ k$, as $g\ e$ makes with g E, in fig. 3, No. 2, draw g L perpendicular to H E, cutting the lower arris G F in L; make the angle K L g equal to the angle $e\ g$ I, fig. 2, No. 3; make L g equal to L K; through g draw M N, parallel to G F; then drawing the rake upon the lower side by the edge of the mould, so that the angle $e\ g$ N, on the said lower side, may be equal to the corresponding angle $e\ g$ E on the upper side; the two sides of the piece that is to form the wreath may be plumbed as before, so as to correspond with the plan when set to its position.

If it is required to draw the rake with each extremity of the concave side of the mould in the arris of the plank as in fig. 3, No. 3, it is only making the angle K L g equal to the angle $e\ g\ k$, fig. 2, No. 3; the rest is drawn, and the plumb side is formed in the same manner as No. 1 and No. 2, fig. 3, which suppose to be done, bend the corresponding part of the falling mould, fig. 2, No. 2, round the convex side of the piece for the wreath; bring the points X and J to the plane at the top, and draw the line of support at the upper extremity upon the end of the wreath; now, bring the upper end of the falling mould close to the extremity of the line of support, and draw a line by the upper edge of the falling mould; cut away the superfluous wood in the manner before described, and this will form the back or top of the rail; then gauge the two vertical surfaces to the same breadth, and cut the superfluous wood away from the under side; this portion of the rail will then be squared. The wreath for the other portion above, is identically of the same form; therefore, if two pieces are prepared by the same moulds and levels, then supposing one of these wreathed pieces to be set in its position for the lower part, and let the upper part be set in the same position, and then inverted, so that the top and bottom ends, and the upper and lower winding surfaces, will have changed places, but each of the vertical surfaces kept still upon the same side; let the lower end of the higher piece be brought to contact with the higher end of the lower piece, that the two planes may coincide and form a joint; the helical solid for half a revolution will be formed out of a straight plank, as required to be done.

The two wreathed portions of a hand-rail are not always alike, as in the preceding example; this may happen in different ways, as from one quarter of the semicircular part being divided into winders, and the other undivided, or, from the rail being placed higher upon the winders than over the flyers; but in whatever way the variation takes place, the application of the principle is the same; it only requires moulds to be constructed for every such variation, or separate part.

The intricacy of the diagrams constructed upon the inventor's former principles, prevented their being generally understood, and very few could practise with success. But the principles here laid down, are so invariable in their result, so simple and expeditious in their application, and so easily to be comprehended, even by a moderate capacity, that they cannot fail of being introduced into general use. They unite the requisite properties of saving labour and stuff, the workman constructs his moulds with ease, and has less superfluous wood to remove. The edge of the plank is kept square, which entirely supersedes the bevelling, and is even in this point attended with a considerable saving of stuff and time, as it allows sufficient wood at the ends to make the heading joints, and as the piece which is cut out of the rail piece from the hollow side, may be turned into use; but if the edge of the plank were bevelled, it would require to be much longer, in order to form the heading joints, and the piece cut out would be too trifling to be employed to any purpose.

In addition to the advantages already enumerated, the workman will be encouraged by the clearness of the different steps of the process, which cannot fail of fully satisfying his mind as to the final result.

It is likewise a great accommodation, that any rail whatever may be cut out of the same thickness of plank, and that the mould may be applied in any direction which the workman pleases to the surface, in order to save wood or match the fibres at the joint.

The art of forming hand-rails round circular or elliptic well-holes, without the use of a cylinder, is entirely new.

Price, the author of the "*British Carpenter*," is the first person who seems to have had any idea of this art; the subsequent writers following his schemes, which were very uncertain in their application, have added nothing to the subject, but have even thrown it into greater obscurity.

The first successful method of squaring the wreath or twist, was invented and published in the "*Carpenter's Guide*," in 1792; and certainly was the first wherein the process was subjected to any thing like geometrical principles, from which the result was attended with success. In the "*Carpenter's Guide*," (generally called simply "*The Guide*,") the formation of the face-mould was regulated by the falling mould or the development of the rail, not by the rise and tread of the steps, as shewn by Price and his followers. When the back or upper surface of the rail had a considerable concavity, as in the case of junction of flyers and winders, the consequence of this regulation in many cases, in the formation of the rail, was the saving of seven or eight inches in the thickness of stuff; and thus, while the method laid down by Price required a plank from six to nine or ten inches in thickness, according to the degree of concavity; that in "*the Guide*" seldom required a plank more than three inches thick, excepting in small well-holes of three or four inches in diameter.

From the great thickness of stuff to cut through, and the quantity to be taken away, the time required to form the piece of wood into a wreath by Price's method, must have been at least double to that in "*the Guide*," and proportionally more so, as the thickness of the plank required by Price, was greater than that in "*the Guide*."

But though considerable advantages were thus obtained in the saving of stuff and labour, it must be observed, that an elevation of the supposed vertical ends of the twisted piece at each joint, and a vertical section of the said piece, were employed to obtain the inclination of the plane of the face of the mould, or that of the faces of the plank; this inclination was only correct when the planes of the faces of the plank were at right angles with the chord plane, or that passing through the chord of the plan of the wreath; but when inclined to the chord plane, required thicker stuff, in proportion to the degree of obliquity, whether more acute or more obtuse.

The method shewn in "*the Guide*," was also the first attempt to spring the plank, that is, to make its plane rest upon three parts of the rail; and though the utmost degree of perfection was not attained, it has been of great use to workmen, as all the hand-rails of stairs in and about London, and in most parts of England, have been executed upon its principles for upwards of thirty years.

To obtain still greater correctness, the inventor tried another method, by setting up three heights, supposed to be on the surface of a curved prism, in the middle of the rail; but this, though still nearer than that published in "*the Guide*," did not give him entire satisfaction; for the resting points being in the middle of the rail, the plane of section which formed the face-mould did not clear all the three sections without cutting into the solid of the wreath.

In the pursuit of truth, he was led to consider what would be the real resting points. It readily appeared, that a level line drawn towards the axis of the well-hole, might be made to coincide in every part with the top of the rail; that if the plane of the top of the plank be supposed to be placed on three vertical sections of the supposed rail in contact with a point in each, or coincident with the whole line of support of one of the sections, and with a point in each of the other two; and the surface of the plank thus inclined be supposed to be prolonged, to intersect the horizontal plane of the base, the intersection would always point out the resting points, and shew their true seats upon the plan. From this consideration, it was evident that the resting point of each section, and consequently each seat, was that extremity of each section next to the intersecting line of the plane of the plank and that of the plan.

This theory being applied to practice, has given the utmost satisfaction, both in the saving of stuff and time; the diagram for the face-mould is completely divested of all cross and oblique lines, and is, perhaps, in the most simple form to which it can possibly be reduced; the plane of section comes in contact with the tops of three vertical sections of the rail in every case whatever, and thus every desideratum is obtained by the most simple means.

Therefore, in practice, if we suppose the section of the rail to be two and a quarter inches horizontally in breadth, and two inches in thickness (as is generally the case,) a plank of two and a half inches thick will be sufficient for a rail, with any degree of concavity or convexity on the back.

We shall now proceed to the illustration of the subject by the figures which represent the solids themselves:—

Fig. 1, is a plan of the cylinder, with the elevation of the helical line, which is found by dividing the height into equal parts, and the circumference of the base into equal parts also, then drawing the lines through the points of division, as in the figure.

Fig. 2, a representation of the solid helix twisting round the cylinder, making a continued rail upon a circular plan; the curvature of the solid helix is, therefore, every where the same. The rail is exhibited as squared; and though it appears as one piece, it must be understood to consist of several wreaths, or lengths, screwed together, each length answering to a quadrantal part of the plan.

Fig. 1.

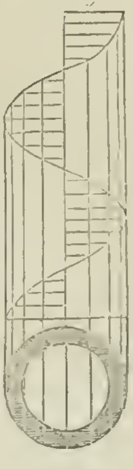


Fig. 2.

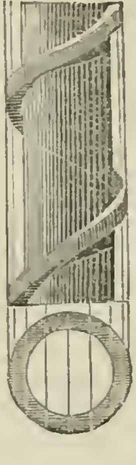


Fig. 3, shews the different sections of a hollow cylinder, cut entirely through the curved surface; the solid exhibits a portion of the said cylinder contained between two parallel planes: No. 1, shews the thickness of the section according to the inclination of the cutting plane; No. 2, shews the section of a semi-cylinder; and No. 3, that of an entire cylinder, cut according to the position of No. 1; the sections No. 2, and No. 3, being turned round, so that the plane of section may be brought into view, in order to make the solid appear.

Fig. 3.

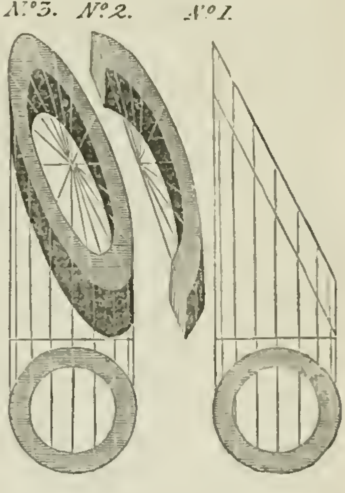


Fig. 4.

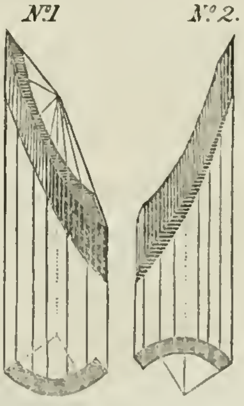


Fig. 5.

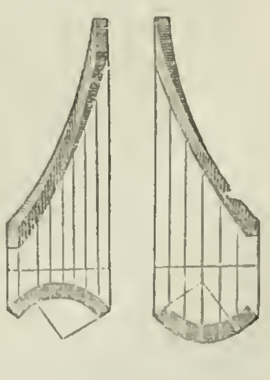


Fig. 4, exhibits a solid section of a hollow cylinder, upon a quadrantal plan, with a small part straight; No. 1, exhibits the convex side, No. 2 the concave side. This figure shews the state of the rail-piece, as prepared by the face-mould, and is therefore bounded by two concentric cylindrical surfaces, and two parallel planes. The falling mould being applied upon the convex side, the superfluous wood is cut away according to a line drawn by the upper edge of the falling mould, in such a manner that the stock of the square, being applied upon the convex side, parallel to the axis, the under edge of the blade may coincide with the top or winding surface of the rail-piece. The thickness of the rail is regulated by running the stem of a gauge first upon the convex side, with the head upon the top or winding surface, and then the stem upon the concave side in the same manner, and cutting away the superfluous stuff between the two gauge lines.

Fig. 5, exhibits the wreath, or rail-piece, as completely squared; No. 1. shews the concave side, with the lower end of the back, or upper surface, and the higher end of the lower surface; and No. 2, the convex side of the cylindric surface, with the upper part of the back, and the lower part of the under side.

The rail exhibited in fig. 2, is only a succession of wreaths, as in fig. 5.

From what has been shewn, it will be easy to conceive how a rail may be executed to any given plan, and to any development of the steps according to that plan.

Though it may be possible to make a rail in one piece, as in fig. 3, No. 3, such a rail will hardly ever come into practice; the representations of the solid sections, in Nos. 2 and 3, are therefore not shewn with a view of being prepared for a rail, but to give a clear view of the different parts of the solid sections of a hollow cylinder.

HANSE Towns, port towns of Germany, of which Lubec and Hamburgh are the chief. They were formerly all of them imperial cities, and confederated for their mutual defence, and the protection of their trade.

HANDSPIKE, a wooden bar or lever to heave round the windlass, in order to raise the anchor from the bottom, or for stowing the anchor, provisions, or cargo, in the ship's hold. The gunner's *Handspike* is shorter than the former, and armed with two claws for managing the artillery.

HANKS, wooden rings fixed upon the stays to confine the stay-sails thereto at different distances; they are used in lieu of grommets, being much more convenient, and of a later invention. They are framed by the bending of a tough piece of wood into the form of a wreath, and fastened at the two ends by means of notches, thereby retaining their circular figure and elasticity.

HARBOUR, a place where ships may ride safe at anchor, chiefly used in speaking of those secured by a boom and chain, and furnished with a mole.

Harbour *Master*, an officer appointed to see that the regulations of an harbour are strictly attended to.

HARD a Lee, the situation of the helm when it is pushed close to the lee side of a ship, in order to tack, or keep her head to the wind. Hence, Hard *a Weather*, when the helm is put close to the weather side of the ship in order to bear-away.

HARDNESS, in Physiology, is the resistance opposed by a body to the separation of its particles. This property depends on the force of cohesion, or on that which chemists call affinity, joined to the arrangement of the particles to their figure and other circumstances.

Hardness, or *Rigidity*, that quality in bodies by which their parts so cohere as not to yield inward, or give way to an external impulse, without instantly going beyond the distance of their mutual attraction; and therefore are not subject to any motion, in respect of each other, without breaking the body.

HARE. *See* Lepus.

HARIOT, or Heriot, in Law, a due belonging to a lord at the death of his tenant, consisting of the best beast, either ox, horse, or cow, which he had at the time of his death, and in some manors the best goods, piece of plate, &c. are called hariots. There is both hariot-service, and hariot-custom; when a tenant holds by service to pay a hariot at his decease, which is expressly reserved in the deed of feofment, this is a hariot service: and where hariots have been customarily paid time out of mind after the death of a tenant for life, this is termed hariot-custom. For hariot-service, the lord may distrain any beast belonging to the tenant, that is on the land. For hariot-custom the lord is to seise, not distrain; but he may seise the best beast that belonged to the tenant, though it be out of the manor, or in the king's highway, because he claims it as his proper goods by the death of his tenant. Nevertheless, where a woman marries and dies, the lord shall have no hariot-custom, because a femme-covert has no goods to pay as a hariot.

HARMATTAN, a wind which blows periodically from the interior parts of Africa towards the Atlantic ocean. It prevails in December, January, and February, and is generally accompanied with a fog or haze that conceals the sun for whole days together. Extreme dryness is the characteristic of this wind; no dew falls during its continuance, which is sometimes for a fortnight or more. The whole vegetable creation is withered, and the grass becomes at once like hay. The human body is also affected by it, so as to cause the skin to peel off, but it stops the progress of infection, and cures almost all cutaneous diseases.

HARMONICA, or Armonica, a musical instrument constructed with drinking glasses. The glasses are blown as nearly as possible in the form of hemispheres, having each an open neck or socket in the middle. The diameter of the largest glass is nine inches, and that of the smallest three inches; between these are twenty-three different sizes, differing from each other a quarter of an inch in diameter. When the glasses are tuned, they are fixed on a round spindle of hard iron, an inch in diameter at the thickest end, and tapering to a quarter of an inch at the smallest. The glasses are all placed within one another; the largest on the biggest end of the spindle, with the neck outwards; the next in size is put into the other, leaving about an inch of its brim above the brim of the first; and the others are put on in the same order. From these exposed parts of each glass the tone is drawn by laying a finger upon one of them as the spindle and glasses turn round. The fingers should be first soaked in water, and rubbed occasionally with fine chalk, to make them catch the glass, and bring out the tone more readily. The tones of this instrument are incomparably sweet beyond those of any other, and when it is once well tuned, it never again wants tuning.

HARMONICAL Arithmetic, is sometimes used for the application of numbers to the science of music.

Harmonical *Curve*, an ideal curve, into which a musical chord is supposed to be inflected, when put into such a motion as to excite sound.

Harmonical *Composition*, in a general sense, includes both harmony and melody, *i.e.* of music or songs, both in a single part, and in several parts.

Harmonical *Mean* and *Proportion*. *See* Mean and Proportion.

Harmonical *Sounds*, such as always make a determinate number of vibrations in the time that one of the fundamentals, to which they are referred, makes one vibration.

HARMONICS, that part of music which considers the differences and proportions of sounds with respect to the acute and grave: in contradistinction to rhyme and metre.

HARMONY of the Spheres, a sort of music conceived by ancient philosophers, and supposed to be produced by the sweetly-tuned motions of the heavenly bodies.

Harmony, in Music, the agreeable result or union of several musical sounds heard at one and the same time.

Harmony *Figured*. Figured harmony is that in which, for the purpose of melody, one or more of the parts of a composition move during the continuance of a chord, through certain notes which do not form any of the constituent parts of that chord.

HARP, a stringed instrument, consisting of a triangular frame, and the cords of which are distended in parallel directions from the upper parts to one of its sides. Its scale extends through the common compass, and the strings are tuned by semitonic interval. It stands erect, and when used, is placed at the feet of the performer, who produces its tones by the action of the thumb and fingers of both hands on the string.

HARPOON, Harping-iron, or Harpago, a spear or javelin, used to strike the whales in the Greenland and South Sea fisheries. The harpoon is furnished with a long shank, and has, at one end, a broad and flat triangular head, sharpened at both edges so as to penetrate the whale with facility: to the other end of this weapon is fastened a long cord called the whale-line, which lies carefully coiled in the boat in such a manner as to run out without being interrupted or entangled. As soon as the boat has rowed within a competent distance of the whale, the harpooner launches his instrument, (on the upper end of which, near the ring, his name is generally engraved,) and the fish being wounded, immediately descends under the ice with amazing rapidity, carrying the harpoon along with him, and a considerable length of the line, which is purposely let down, to give him room to dive. Being soon exhausted with the fatigue and loss of blood, he reascends in order to breathe, where he presently expires, and floats upon the surface of the water, when they approach the carcase by drawing in the whale-line. The line is sixty to seventy fathoms long, and made of the finest and softest hemp, that it may slip the easier; if not well watered, by its friction against the boat, it would soon be set on fire; and if not sufficiently long, it would be soon overset, as it frequently is. With the harpoon they also catch other large fish, as sturgeons, &c.

HARPSICHORD, a stringed instrument, consisting of a case framed of mahogany or walnut-tree wood, and containing the belly or sounding-board over which the wires are distended supported by bridges. In the front the keys are disposed, the long ones of which are the naturals, and the short ones the sharps and flats. These keys being pressed by the fingers, their enclosed extremities raise little upright oblong slips of wood called jacks, furnished with crow-quill plectrums, which strike the wires. The great advantage of the harpsichord beyond most other stringed instruments, consists in its capacity of sounding many notes at once, and forming those combinations, and performing those evolutions of harmony, which a single instrument cannot command.

HARRIOT, Thomas, an eminent English mathematician and astronomer, was born at Oxford in 1560; who, before he was twenty years of age, had acquired so great a reputation for his mathematical knowledge, that he was appointed preceptor to Sir Walter Raleigh, who was ever after his steady patron.

HART'S Horn, the horns of the common male deer, to which many very extraordinary medicinal virtues were attributed, and indeed to nearly all parts of its body; but the experience of late years gives no countenance to them. The horns are of nearly the same nature as bones, and the preparations of them by heat are similar to those from solid animal substances in general. Consequently the articles denominated *spirit of hartshorn*, and *salt of hartshorn*, though formerly obtained only from the horns of different species of deer, are now chiefly prepared from bones. The former of these, which is a volatile alkali of very penetrating nature, is an efficacious remedy in nervous complaints and fainting-fits: and salt of hartshorn has been successfully prescribed in fevers. The scrapings or raspings of the horns, under the name of *hartshorn shavings*, are variously employed in medicine. Boiled in water, the horns of deer give out an emollient jelly, which is said to be remarkably nutritive. *Burnt hart's horn* is employed in medicine. The horns of the stag are used by cutlers and other mechanics for the handles of knives and cutting instruments of different kinds.

HARVEST Fly, in Zöology, a large four-winged fly of the cicada kind.

HAT Making. Hats are commonly made of wool, or of feathers, or of straw. The wools of kids, hares, rabbits, and beavers are used to cover the original material in all woollen hats; and in general the quality of the hat depends on the proportions of good or fine wool employed in its manufacture. The different processes in hat-making are *bowing*, *hardening*, *working*, *shaping*, *dying*, *stiffening*, *steaming*, *and ironing*.

Bowing, consists in teasing or dressing the wool by means of a hand bow which the workman twangs with a knobbed stick. *Hardening* is merely the pressing of the wool so bowed to make it bear handling, by means of a cloth that covers the stuff, and enables the hatter to form it into a conical shape. *Working* is done by a battery, consisting of a kettle of water (acidulated with sulphuric acid) and eight planks of wood joined together, and meeting in the kettle at the middle. The liquor being heated, the article is dipped from time to time, and worked on the planks with a roller, and by rolling it up, and opening it again. *Shape* is given by laying the conical cap on a block, the size of the crown of the hat, and thus tying it round with a packthread, called a commander, and afterwards with a piece of iron, or copper bent for the purpose, the workman gradually drives down the commander all around, till he has reached the bottom of the block, and the crown is formed; what remains below the string, is the brim. *Dyeing.* The nap of the hat being raised with a wire brush, it is dyed in a liquid prepared of logwood, and green copperas and blue vitriol, the sulphates of iron and copper. The copper holds ten or twelve dozen hats, which are kept boiling for three-quarters of an hour, when they are taken out and set to cool, and returned to the dye; and this ten or twelve times successively. *Stiffening* is effected with beer grounds and glue. The workman has two boilers, one the grounds of strong beer, applied to the inside of the crown, to prevent the glue from oozing through; another containing the glue stiffeoing, applied after the beer-grounds are dried, and then only upon the lower face of the flap, and the inside of the crown. *Steaming.* The hat is now placed on the steaming-bason, which is a small hearth, or fire-place, raised three feet high, with an iron plate over it, exactly covering the hearth. On this plate the workman first spreads cloths, which being sprinkled with water to secure the hat from burning, it is placed on them with the brim downwards. When moderately hot, the workman strikes gently on the brim with the flat of his hand, to make the jointings incorporate, so as not to appear. *Ironing.* The hat is put again on the block, and brushed and ironed on a bench, called the stall-board. This is performed with an iron like that used in ironing linen; which being rubbed over each part of the hat, with the assistance of the brush, smooths and gives it a gloss. The hat is then lined and trimmed for sale. These latter operations are for the most part performed by women.

HATCH, or Hatchway, a square or oblong opening in a ship's deck, forming a passage from one deck to another, or from the deck to the hold. In large ships there are several hatchways, as the *fore*, the *main*, and the *after* hatchways. In fact, hatches are moveable trap-doors.

HATCHES, also denote flood-gates set in a river, &c. to stop the current of the water.

HATCHING, the maturating fecundated eggs, whether by the incubation and warmth of the parent bird, or by artificial heat, so as to produce young chickens alive.

The art of hatching chickens by means of ovens, has long been practised in Egypt; but it is there only known to the inhabitants of a single village named Berme, and to those that live at a small distance from it. Towards the begining of autumn they scatter themselves all over the country, where each person among them is ready to undertake the management of an oven, each of which is of a different size, but in general they are capable of containing from forty to fourscore thousand eggs. The number of these ovens placed up and down the country is about thre hundred and eighty six, and they usually keep them working for about six months. As therefore, each brood takes up, in an oven, as under a hen, only twenty-one days, it is easy in every one of them to hatch eight different broods of chickens. Every Bermean is under the obligation of delivering to the person who intrusts him with an oven, only two-thirds of as many chickens as there have been eggs put under his care; and he is a gainer by this bargain, as more than two-thirds of the eggs usually produce chickens. In order to make a calculation of the number of chickens yearly so hatched in Egypt, it has been supposed that only two-thirds of the eggs are hatched, and that each brood consists of at least thirty thousand chickens: and thus it would appear that the ovens of Egypt give life yearly to at least ninety-two millions six hundred and forty thousand of these animals!

Hatching *of Fish*. The Chinese hatch the spawn of fish, by collecting it on the margin and surface of the water, and then filling the shell of a newly laid egg with the gelatinous matter which contains the spawn. The hole in the egg is waxed over, and it is put under a sitting hen. At the expiration of a certain number of days, they break the shell in water warmed by the sun. The young fry are presently hatched, and are kept in pure fresh water till they are large enough to be thrown into the pond with the old fish. The sale of spawn for this purpose forms an important article of trade in China.

HATCHMENT, in Heraldry, is the coat of arms of a dead person, usually placed on the front of a house, by which is known the rank of the deceased person while living, whether bachelor, maid; husband, wife; widow, or widower, &c.

HAUL THE WIND, (TO) to direct the ship's course nearer to that point of the compass from which the wind arises: for instance—suppose a ship sails south-west with the wind northerly, and some particular occasion renders it necessary to haul the wind further to the westward: to perform this operation, it is necessary to arrange the sails more obliquely with her keel; to brace the yards more forward by slackening the starboard, and pulling in the larboard braces, and to haul the lower sheets further aft, and finally to put the helm aport, *i. e.* over the larboard side of the vessel. As soon as her head is turned directly to the westward, and her sails are trimmed accordingly, she is said to have hauled the wind four points, that is to say, from S. W. to W. She may still go two points nearer to the direction of the wind, by disposing her sails according to the greatest obliquity, or, in the sea-phrase, by trimming all sharp; and in this situation she is said to be close-hauled, as sailing W. N. W.

HAUTBOY, a musical instrument of the wind kind, shaped much like the flute, only that it spreads and widens towards the bottom, and is sounded through a reed.

HAW FINCH, in Ornithology, the English name of a bird known among authors by the name of coccothraustes.

HAWKERS and PEDLARS, are such dealers or itinerary petty chapmen who travel to different fairs or towns with goods or wares, and are placed under the control of commissioners, by whom they are licensed for that purpose, pursuant to stat. 8 and 9 William III. c. 25, and 29 Geo. III. c. 26. Traders in linen and woollen, sending goods to markets and fairs, and selling them by wholesale; manufacturers selling their own manufactures, and makers and sellers of English bone-lace, going from house to house, &c. are excepted out of the acts, and not to be taken as hawkers.

HAWSE, the situation of the cables of a ship when moored with two anchors, one on each bow. When the cables cross each other, and rub together, the *hawse is foul*. HAWSE *Plugs* are thrust into the hawse holes to keep out the water.

HAZARD, a game on dice, without tables. It is played with only two dice, and as many may play at it as can stand round the largest round table.

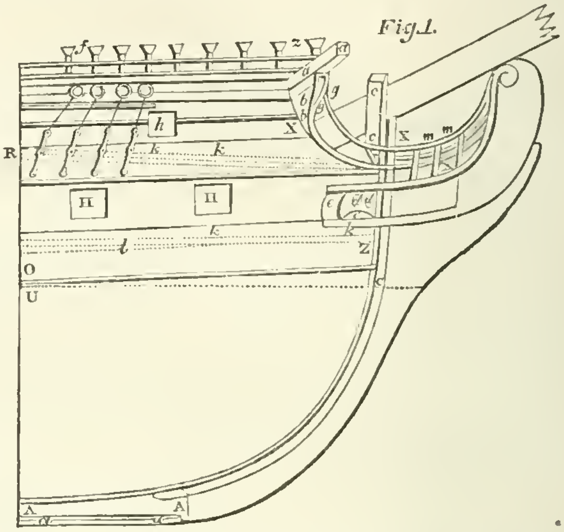
Two things are chiefly to be observed, *viz.* main and chance, the latter belonging to the caster, and the former, or main, to the other gamesters. There can be no main thrown above nine, nor under five, so that five, six, seven, eight, and nine, are the only mains flung at hazard. Chances and nicks are from four to ten; thus, four is a chance to nine, five to eight, six to seven, seven to six, eight to five; and nine and ten a chance to five, six, seven, and eight; in short, four, five, six, seven, eight, nine, and ten, are chances to any main, if any of these nick it not. Now nicks are either when the chance is the same with the main, as five and five, or the like; or six and twelve, seven and eleven, eight and twelve. Here observe, that twelve is out to nine, seven, and five; eleven is out to nine, eight, six, and five, and ames-ace and deuce-ace, are out to all mains whatever.

HEAD, an ornamental figure erected on the continuation of a ship's stem, as being expressive of her name, and emblematical of war, navigation, commerce, &c. The heads which have any affinity to war or navigation, are in general either historical, as referring to some of the deities or heroes of antiquity; or allegorical, as alluding to some of the natural consequences of battle, or the virtues most essential to life exposed to perpetual danger. Thus, in the former sense, they represent a Neptune, an Alcides, a Mars, an Achilles, a Minerva, or a Jason; and in the latter they produce a Magnanimous, an Intrepid, a Revenge, or a Victory. Image heads are those founded on practical fiction, and should be bold, warlike, and classical,—such as Hercules brandishing his club over the heads of Cerberus; Jupiter riding on his eagle, and armed with his thunders, &c. Emblematic heads consist of appropriate figures,—such as an eagle, denoting dignity, force, and velocity; a dragon, denoting power, vigilance, &c.

HEAD, is also used in a more enlarged sense, to signify the whole front or forepart of a ship, including the bows on each side; the head therefore opens the column of water through which the ship passes when advancing; hence we say, *Head-sails*, *Head-way*, *Head-sea*, &c. It is evident that the forepart of a ship is called its head, from the affinity of motion and position it bears to a fish, and in general to the horizontal situation of all animals while swimming.

Thus, fig. 1 represents one side of the forepart of the head of a 74-gun ship, together with part of the bow keel, and gunnel, which will be better understood from this description:—A A, the keel; *a*, *a*, false keels; A C, the stem; *a*, *a*, the cat head; *b*, *b*, its props, or supporter; *c*, *c*, the knight head, or bollard timber which secures the inner end of the bowsprit; *d*, *d*, the hause holes; *e*, *e*, the naval hoods; *f*, the davit-chock; *g*, the bulk head.

Fig. 1.

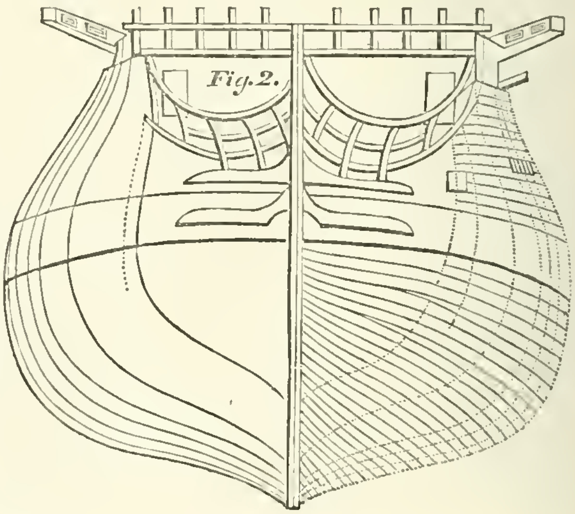


H H, gun ports of the lower deck; *h*, gun ports of the upper deck. I, I, the channel, with their dead eyes and chain plate. *i*, the gripe or fore foot, which unites the keel with the stern, forming a part of either.

h, *k*, the decks; *l*, the convexity of the beams; *m*, *m*, timbers of the head and part of the bowsprit; X, the rails of the head lying across the timbers; Q Z, the forepart of the main wale: R X, forepart of the channel wale. U C, the load water line.

Fig. 2 represents the head view of a ship, with the projection of her principal timbers and all the planks laid on one side.

Fig. 2.



HEADBORROW, or Headborough, the chief of the frank pledge. He was called also burrowhead, bursholder, third-burrow, tithing-man, chief-pledge, or burrow-elder. He is now occasionally called a constable.

HEALTH, is a right disposition of the body, and all its parts.

HEARING. *See* Sound. The organ of hearing is the ear, and particularly the auditory nerve and membrane.

HEAT, in Natural Philosophy, is one of the effects of fire or caloric, indicated by an increase of temperature, and the sensation it produces on the organs of feeling. Various hypotheses have been advanced, both by ancient and modern philosophers, to account for the phenomena of heat, some considering it as a body, *sui generis*, and others only as a quality common to all bodies. It would answer very little purpose, if our limits would admit of it, to detail the various notions that have been advanced on this subject; we shall, therefore, merely state the opinions of some of the best informed philosophers amongst the moderns, though the grand question, as to the materiality of heat, is not yet satisfactorily determined. With respect to the solar heat, we observe then, that, by present opinion, the sun's rays are twofold; one sort emits light, the other heat; called in science calorific and luminous rays. This division of the solar rays into calorific and luminous, established as it is upon such undoubted premises, Dr. Thompson considers as nearly putting an end to the dispute, by demonstrating the existence of caloric as a peculiar substance; at least it is putting it upon the same footing in this respect as light, the materiality of which is not disputed by many who argue on the other side with regard to heat. The greatest degrees of heat which are known, have been produced by concentrating the solar rays with a mirror, or lens, or by supplying a blow-pipe with oxygen gas. The greatest degree of cold known to have been produced, has been obtained by mixing snow with certain salts, as muriat of lime. If this be mixed with dry, light snow, and stirred well together, the cold produced will be so intense, as to freeze mercury in a few minutes. Salt and snow also produce a great degree of cold.

Heat *Animal.* The temperature which animals, and even vegetables, maintain during life, above that of surrounding objects, is a very striking phenomenon. By general analogies, it has frequently been referred to the process of combustion; and from facts more distinctly pointed, the doctrine, that it depends upon the absorption of oxygen, has been advanced by modern chemists. It has, however, been found, by actual experiment, that the lungs of animals are usually the coldest part of the body; and hence it has been doubted whether the above theory was correct, and recourse has been had to the supposition, that animal heat was the effect of electricity.

Heat, in Geography, the diversity of heat of climates and seasons arising chiefly from the different angles under which the sun's rays strike upon the surface of the earth. The different degrees of heat and cold in different places depend, however, in a very great measure, upon the accidents of situation with regard to mountains and valleys, and the soil.

The following table of the heat of different climates is computed for every tenth degree of latitude, to the equinoctial and tropical sun; by which an estimate may be made of the intermediate degrees.

Lat.	Sun in Aries and Libra.	Sun in Cancer.	Sun in Capricorn.
0	20000	18341	18341
10	19696	20290	15854
20	18797	21737	13166
30	17321	22651	10124
40	15321	23048	6944
50	12855	22994	3798
60	10000	22773	1075
70	6840	23543	000
80	3473	24673	000
0	0000	25055	000

Latent **Heat**, is a phrase used by Dr. Black, arising from the discovery that a large portion of heat sometimes disappears, or is absorbed by a body, without any increase of temperature. This commonly happens when a body from a solid becomes liquid, or from a liquid becomes aëriform; and sometimes, when two bodies of the same temperature combine, a great degree of cold is produced; but when a due portion of heat is acquired from the surrounding bodies, the temperature is restored. The heat which disappears in these cases is what is called *latent point*. *See* Evaporation.

HEATH. *See* Erica.

HEAVEN, in the Ancient Astronomy, denoted an orb or circular region of the ethereal heaven. The ancient astronomers assumed as many different heavens as they observed different celestial motions. These they supposed to be all solid, as thinking they could not otherwise sustain the bodies fixed in them; and spherical, that being the most proper form for motion. Thus they have seven heavens for the seven planets, the Moon, Mercury, Venus, the Sun, Mars, Jupiter, and Saturn. The eighth was the fixed stars, which was particularly denominated the firmament. Ptolemy adds a ninth heaven, which he calls the *primum mobile:* after him two crystalline heavens were added by Alphonso, king of Castile, to account for some irregularities in the motions of the other heavens: and, lastly, an empyrean heaven was drawn over the whole, for the residence of the Deity; which made, in all, twelve heavens. But others admitted many more heavens, according as their different views and hypotheses required; Eudoxus supposed 23, Regiomontanus 33, Aristotle 47, and Fracaster no less than 70.

HEAVINESS, in general the same with *Gravity* and *Weight*.

HEDERA, or Ivy, a genus of the pentandria monogynia class and order. Natural order of hederaceæ. Caprifolia, Jussieu. There are six species, with several varieties. The roots of the helix or ivy are used by leather-cutters to whet their knives upon. Apricots and peaches covered with ivy during the month of February, have been observed to bear fruit plentifully. The leaves have a nauseous taste; they are given to children in Germany, as a specific for the atrophy. The common people of England apply them to issues; and an ointment made from them is in great esteem among the Highlanders of Scotland as a ready cure for burns. Horses and sheep eat the plant; goats and cows refuse it.

HEDGES, in agriculture, are either planted to make fences round enclosures, or to divide the several parts of a garden. When designed as outward fences, they are planted either with hawthorn, crabs, or blackthorn; but for gardens, some prefer evergreens, in which case the holly is best, next the yew, then the laurel, laurustinus, phillyrea, &c.; others prefer the beech, the hornbeam, and the elm.

HEDYSARUM, in Botany, a genus of the Diadelphia Decandria class and order. Natural order of Papilionaceæ or Leguminosæ. Essential character: corolla keel transversely obtuse; legume jointed, with one seed in each joint. There are ninety species, only one of which is a native of Great Britain; *viz.*, H. onobrychis saintfoin, or cockshead, and but ten which are natives of Europe. Most of these are perennial.

HEGIRA, in Chronology, signifies the epoch or account of time used by the Mahomedans, who begin their computation from the day that Mahomet was obliged to abandon the city of Mecca, July 16, 622. The years of the hegira are lunar ones, of 354 days; and therefore to reduce these to the Julian Calendar, we must multiply the years of the hegira by 354, and divide the product by 365¼; to which add 622, the date at which this epoch commenced, and the result will be the Julian year required.

HEIGHTS and Distances, *The Mensuration of.* In the mensuration of heights and distances, instruments of various kinds are used for determining angles, and the distances between remote and inaccessible objects. The fittest instrument for taking *vertical* or *horizontal angles*, is a *theodolite*, furnished with a compass and level, one or two telescopes, and a vertical arc. Angles *oblique* to the horizon may be taken with a *Hadley's quadrant* or *sextant*, and then reduced by calculation to their projection on the horizontal plane. Angles, both *horizontal* and *vertical*, may also be taken with Hadley's quadrant; observing, that in *near objects* the quadrant is to be adjusted to the *direct object;* and that, in taking *vertical* angles with it, an *artificial horizon* should be used, and the image of the object, reflected from the glasses of the quadrant, brought to coincide with that in the artificial horizon. *See* THEODOLITE and QUADRANT. *See* ALTITUDE, from pages 28 to 31.

Bases or *distances* may be measured with *Gunter's chain*, or the common 50 feet *tapes*, or *poles*, or *rods*, of a convenient length, and formed of such matter as is least liable to contract or expand in length, during the measurement. The *use* of instruments is best acquired under the direction of a person practically acquainted with their application and several adjustments.

Problem 1.—*To find the height of an accessible object.—Rule.* Measure the distance between the bottom of the object, and any convenient station, on the same horizontal plane; and at that station observe the angle of elevation. Then say, As radius is to the tangent of the angle of elevation, so is the horizontal distance to the height of the object above the horizontal plane passing through the eye of the observer, to which the height of the eye being added, the sum will be the height of the object. *See* Probs. 1 and 4, ALTITUDE.

Example.—Let the horizontal distance A B (fig. 1) be 200 feet, and the angle of elevation C D E 37° 35′, the height of the eye being 5 feet; what is the height of the object B C?

As radius	=	T. 45°	=	10·0000000
To tangent C D E	=	37° 35′	=	9·8862878
So is distance A B	=	200	=	2·3010300
To the height C E	=	153·92	=	2·1873178
Add height of the eye	=	5·		
Height of the object B C	=	158·92		

Remarks. 1. In measuring heights, the station of the observer should be chosen so, that the angle of elevation may be as near to 45° as possible, because the less error in the altitude will arise from an error in the angle, the nearer the angle is to 45°. 2. When the angle of elevation is 45°, the height above the plane of the eye will be equal to the distance; when the angle is 26° 34′, the height will be equal to half the distance, and when the angle is 30°, the height will be equal to half the hypotenuse.

The angle of depression F C D is = the angle of elevation E D C, for they are alternate angles, and F C is parallel to D E.

Fig. 1.

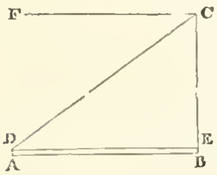
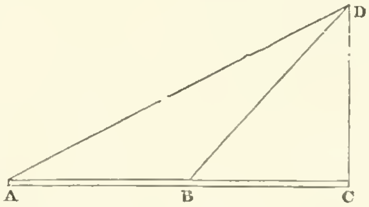


Fig. 2.



Problem 2.—*To find the height of an inaccessible object.—Rule.* Let C D (fig. 2) represent the object of which the height is to be found; at any two convenient stations A and B, in the same vertical plane with C D, observe the angles of elevation D A C, D B C, and measure the distance A B. Then, because the exterior angle D B C is equal to the two interior angles B D A, D A B; if D A B be subtracted from D B C, the angle B D A will remain. Now, in the triangle D A B, as sine D is to sine A, so is A B to B D; and in the triangle D B C, as sine C (rad.) to sine B, so is B D to C D. *See* Probs. 1 and 5, ALTITUDE, where, in fact, these two problems are given; and their introduction here is defensible on no other ground than the Alphabetical Title of our work, for we abjure repetition as needless waste of our own property.

Example.—The angle of elevation of a tower at a station on the same horizontal plane was 48°, and at another station, on a level with the former, and 200 feet farther on, in the same direction, the angle of elevation was 26° 45′, the height of the eye being 5 feet; what was the height of the tower?

48° — 26° 45′ = 21° 15 = A D B.

To find B D.

; S,ADB = 21° 15′ = 9·5592338
: S,DAB = 26° 45′ = 9·6533075
: : A B = 200 = 2·3010300

; B D = 248·37 = 2·3951037

To find C D

: S,C = 90° = 10. 000000
: S,DBC = 48° = 9 8710735
: : B D = 248·37 = 2·3951037

: C D = 184·57 = 2·2661772

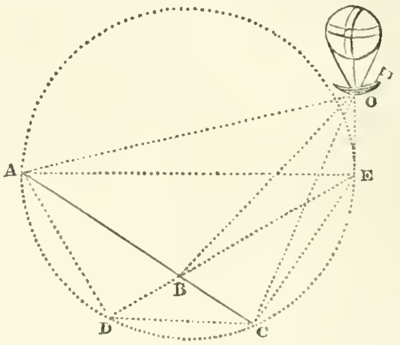
Height of the eye = 5·
Height of the tower = 189·57 feet.

The operation may be performed rather more concisely, as follows:—To the sines of the observed angles of elevation add the co-secant of the difference between these angles, and the logarithm of the distance between the stations A and B, the sum, rejecting 30 from the index, will be the logarithm of the height of the object.

Problem 3.—*Given the angles of elevation of any distant object, taken at three places in a horizontal straight line, which does not pass through the point directly below the object; and the respective distances between the stations; to find the height of the object, and its distance from either station.*

Let A E C (fig. 3) be the horizontal plane, E O the perpendicular height of the object O above that plane, A, B, C, the three places of observation, O A E, O B E, O C E, the respective angles of elevation, and A B, B C, the given distances. Since the triangles A E O, B E O, C E O, are all right-angled at E, the distances AE, B E, C E, will evidently be as the cotangents of the angles of elevation at A, B, C, respectively. Now the point E may be determined, so that those lines may have that ratio as follows:—

Fig. 3.



Construction.—Find A D, D C, thus, *Cot* B : *Cot* C : : A B : A D, and *Cot* B : *Cot* A : : B C : C D. Make the triangle A D C, about which describe a circle. Join D B, and produce it till it meet the circle in E, the point in the horizontal plane perpendicularly below O;—or, the point E may be found without describing the circle, thus: Having found A D, C D, as before, and made the triangle A D C, join D B, and draw A E so that the angle E A C may be equal to the angle B D C; then will A E meet B D produced in E.

Solution.—In the triangle A C D, of which the three sides are known, find the angle C A D. Again, in the triangle A B D, of which the sides A B, A D, and the included angle B A D are known, find the side B D. Then, because the triangles B D C, B A E, are similar, and also the triangles B D A, B C E, as B D : C D : : A B : A E; also, B D : A B : : B C : B E, and B D : A D : : B C : C E. Lastly, Radius : Tan. angle of elevation at A, B, or C : : the distance of E from that station : the height (E O) required.

Example.—Three observers, A, B, C, in a straight line, take, at the same instant, on a signal, the altitude of a balloon. A finds it 15°, B 18°, and C 20°; also, B is 1000 yards from A, and C 1500 yards from B; the perpendicular height of the balloon is required?

To find the line A D.

: Cot B = 18° = 0·4882240
, Cot C = 20° = 0·4389341
.: A B = 1000 = 3· 000000

: A D = 892·709 = 2·9507101

To find the line C D.

: Cot B = 18° = 0·4882240
: Cot A = 15° = 0 5719475
: : B C = 1500 = 3·1760913

: C D = 1818·925 = 3 2598148

To find the angle C A D.

A C = 2500 log. 3·3979400
A D = 892·709 .... 2·9507101

C D = 1818·925 .... 6·3486501

2) 5211·634 13·6513499
2605·817 log. 3·4159439
186·892 .... 2·8959151

19·9632089
16° 33′ 32″ cos. 9 9816044
2

33° 7′ 4″ = the angle C A D.

To find the line B D.

: B A + A D = 1892·709 = 3·2770839

: B A − A D = 107·291 = 2·0305633
: : Tang. ½ (D + B) = 73° 26′ 28″ = 10·5267586

: Tang. ½ (D − B = 10° 47′ 38″ = 9·2802380

The angle A B D = 62° 38′ 50

Hence, Sine ∠ A B D : Sine B A D : : A B : B D.

i. e. : S,A B D = 62° 38′ 50″ = 9·9485080

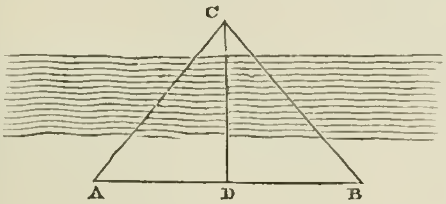
: S,B A D = 33° 7′ 4″ = 9·7374804
: : A D = 892·709 = 2 9507101

: B D = 549·139 = 2·7394825

To find A E.	*To find* E O.
: B D = 2·7396825	: Rad. sine 90° = 10·0000000
: C D = 3·2598148	: Tang. 15° = 9·4280525
: : A B = 3·00000000	: : A E = 3·5201323
: A E = 3312·32 = 3·5201325	: E O = 887·53 = 2·9481848

Problem 4.—*To find the distance of an inaccessible object,* fig. 4.—Let C be any inaccessible object, and A, B, points from which the distance of that object is to be found. Measure the distance AB, and observe the angles B A C, ABC. Then sine C : sine B : : B A : A C; and, sine C : sine A : : A B : B C.

Fig. 4



Example.—Let the angle A be 86° 52′, the angle B 78° 47′, and the base A B 10,110 feet; what is the distance between A and C?

Here by the Rule.

: Sine ∠ C = 14° 21′ = 9·3911794

: Sine ∠ B = 78 47 = 9·9916241
: : A B = 10,110 = 4·0017512

: A C = 40012·5 = 4·6021959

or, A C is 7 *miles* 4 *fur.* 137 *yards* 1½ *feet.*

The distances A C, B C, fig. 5, may be determined without the aid of an instrument to measure the angles, thus:—Continue C A, C B, to any two points F, G, and measure A B, A F, A G, B F B G; then the three sides of the triangles A B G, B A F, being known, the angles AB G and B A F may be found, and consequently their supplements C B A, C A B; from which compute A C, B C, by the rule. The perpendicular distance D C may be found thus:—Calculate either side as A C by the rule, then from A C and the adjacent angle A, find D C.

Fig. 5.

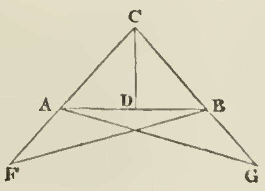
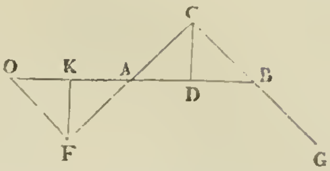


Fig. 6.

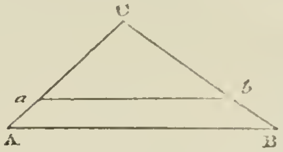


Or, produce C A to F, fig. 6, C B to G; measure off A O = A B, and trace O F parallel to B G; then the triangle O F A is equal and similar to the triangle A C B. Consequently, if from the vertex F we trace a line F K perpendicular to A O; this new line K F = C D.

Problem 5.—*To find the distance between two objects* (A and B), *the distance of each from a third object* (C) *being known, and also the angle* (C) *at that object which the required distance subtends.*

Rule. Let A C, B C, and the angle A C B be given (fig. 7) from these *data*, it is plain that A B may be found by the rule for the second case of Plane Trigonometry; or, $A B = \surd (A C^2 + B C^2 - 2 A C. B C. \cos. C.)$

Fig. 7.



Example.—In order to determine the distance between two houses A and B, which could not be done by direct measurement, I measured the distance of each of them from a point C, *viz.* A C = 600 yards, B C 700 yards, then at C, I took the angle A C B = 56° 12′. Required the distance A B?

: B C + A C = 1300 = 3·1139434

: B C − A C = 100 = 2·0000000
: : Tan ½ (A + B) = 61° 54′ = 10·2724992
: Tan ½ (A − B) = 8° 11′ 52″ = 9·1585558

A = 70° 5′ 52″
: S,A = 70° 5′ 52″ = 9·9732549

: S,C = 56 12 = 9·9195929
: : B C = 700 = 2 8450980

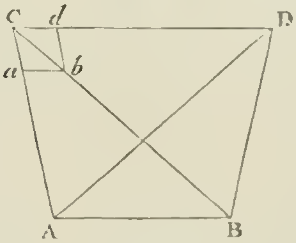
: A B = 618·63 = 2·7914360

or $A B = \surd (600^2 + 700^2 - 1200 \times 700 \times ·556296) =$ 618 63 yards.

Remark.—If the lines measured from A and B to C be continued beyond C, till the parts of them beyond C be equal to A C, B C, then will the distance between the extremities of the lines so continued, be equal to that between A and B, without calculation.

Problem 6.—*To find the distance between two inaccessible objects.*—*Rule.* Let C and D (fig. 8) be two inaccessible objects, the distance between which is required. Measure any base A B; at A find the angles C A D, D A B, and at B find the angles A B C, C B D. In the triangle A B C, in which the angles and the side A B are given, find C B; in like manner, in the triangle A B D, find B D. Then in the triangle C B D, of which the sides C B, B D, and the included angle C B D, are given, find the side C D.

Fig. 8.



Example.—Let C and D be two houses on the further side of a river; required their distance, from the following *data, viz.* A B = 1000 links, the angle C A D = 42° 45′, D A B = 54° 12′, A B C = 57° 33′, and C B D = 50° 19′?

1. *In* A B C, *to find* B C.	2. *In* A B D, *to find* B D.
: S,C = 25° 30′ = 9·6339844	: S,D = 17° 56′ = 9 4881210
: S,A = 96° 57′ = 9·9967971	: S,A = 54° 12′ = 9·9090550
: : A B = 1000 = 3·0000000	: : A B = 1000 = 3·0000000
: B C = 2305·75 = 3·3628127	: B D = 2634·09 = 3·4206310

3. *In* C B D, *to find an angle* C D.

: B D + B C = 4939·84 = 3·6937129
: B D — B C = 328·34 = 2·5163238
: : Tan ½ (C + D) = 61° 50′ 30″ = 10 3282013
: Tan ½ (C — D) = 8° 3′ 18″ = 8·1508122

B C D = 72° 53′ 48″
: S,C = 72° 53′ 48″ = 9·9803561
: S,B = 50° 19′ = 9·8862568
: : B D = 2634·09 = 3·4206310
: C D = 2120·95 = 3·3265317

2120 95 links.

In like manner, the distances, taken two and two, between any number of remote objects placed around a base line, may be determined.

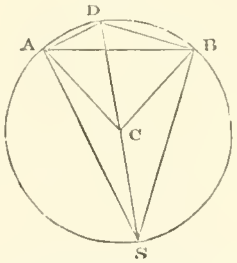
Problem 8.—*Given the distances between three objects* (A, B, C,) *and the angular distances between these objects at a station* (S) *in the same plane, to find the distance between that station and each of the objects.*

Of this problem there are several cases.

Case 1. When the station S is without the triangle A B C, fig. 9.

Construction. Make the triangle A B C; at A, make the angle D A B = the given angle D S B or C S B; at B, make the angle A B D = A S C or A S D. Then through the points A, B, D, describe a circle; join D C, and produce it till it meet the circle in S, the station of the observer; and join S A, S B.

Fig. 9.

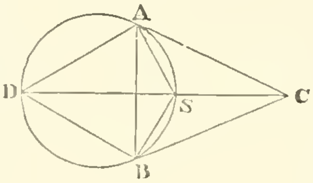


Solution. In the triangle A B C, of which the three sides are known, find the angle B A C. In the triangle A B D, of which the angles and the side A B are known, find the side A D. In the triangle C A D, of which two sides A C, A D, and the included angle C A D are known, find the angle A C D. In the triangle A S C, of which the angles and the side A C are known, find the sides S A, S C. And in the triangle A S B, of which the angles and the side A B are known, find S B.

Case 2. When the station S is within the triangle A B C, as in fig. 10.

Construction. Make the triangle A B C; make the angles B A D, A B D equal to the supplements of the given angles B S C, A S C, respectively. Through the points A, B, D, describe a circle; join D C, which will cut the circle in S, the station of the observer.

Fig. 10.

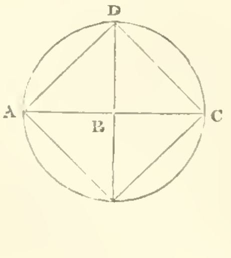


Solution. This case is calculated in the same manner as the last.

Case 3. When the three objects are in one straight line, as in fig. 11.

Construction. This case is constructed in the same manner as Case 1.

Fig. 11.



Solution. In the triangle A D C, of which the angles and the side A C are known, find A D. In the triangle A B D, of which the sides A B, A D, and the included angle B A D are known, find the angle A B D = S B C; the supplement of which ABS = D B C. In the triangle A B S, of which the angles and the side A B are known, find S A, S B. And in the triangle A S C, of which the angles and A C are known, or in the triangle B S C, of which the angles and B C are known, find S C.

Case 4. When the station S is in one of the sides of the triangle, or in one of the sides produced, as in figs. 12 and 13.

Fig. 12.

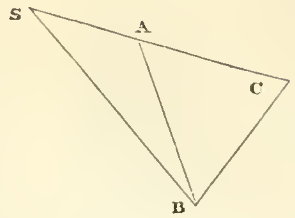
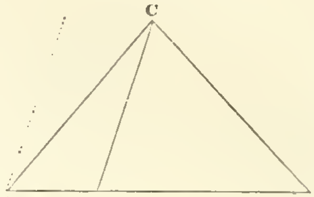


Fig. 13.



Solution. Find the angle B A C from the three sides. Then, when S is situate as in fig. 13, the angles of the triangle A S C, and the side A C, are given to find C S, A S, and consequently B S. And when S is situate as in fig. 12, the angles of the triangle S A B, and the side A B, are given to find B S, A S, and consequently C S.

Example 1.—There are three objects A, B, C, (fig. 9) the distances of which from one another are as follows:—A D = 424, A C = 213, and B C = 262 yards; I desire to know my distance from each of these objects at a station S without the triangle A B C, where I observed the angle A S C to be = 13° 30′, and B S C = 29° 50′ ?

A B = 424 log. 2·6273659
A C = 213 log. 2·3283796
B C = 262 4·9557455
2) 899 15·0442545
449·5 log 2 6527297
187·5 log. 2·2730013
2) 19·9699855
14° 58′ 33″ cos. 9·9849927
2
29° 57′ 6″ = B A C

2. *In* A B D *to find* A D.

[*] : S,D = 136° 40′ = 9·8364771
: S,B = 13° 30′ = 9·3681853
: : A B = 424 = 2·6273659
: A D = 144·236 = 2·1590741

3. *In* A C D *to find the angle* C.

: A C + A D = 357·236 = 2·5529552
: A C — A D = 68·764 = 1·8373611
: : Tan ½ (D + C) = 60° 6′ 27″ = 10·2404445
: Tan ½ (D — C) = 18° 30′ 47″ = 9·5248504

C = 41° 35′ 4″ = supplement of the angle A C S, and also the exterior angle of the triangle A S C; whence, 180° — A C D = A C S, and A C D — A S C = C A S.

4. *In* A S B *to find* B S.

: S,S = 43° 20′ = 9·8364771
: S,A = 58° 2′ 46″ = 9·9286387
: : A B = 424 = 2·6273659
: B S = 524·236 = 2·7195275

5. *In* A C S *to find* A S and C S.

: S,S = 13° 30′ = 9·3681853
: S,C = 138° 24′ 20″ = 9.8220724
: : A C = 213· = 2 3283796
: A S = 605·712 = 2·7822667
: S,S = 13° 30′ = 9·3681853
: S,A = 28° 5′ 40″ = 9 6729530
: : AC = 213· = 2·3283796
: C S = 429·682 = 2·6331473

Example 2.—There are three objects A, B, C, fig. 9, the distances of which from one another are as follows:—A B = 314 yards, A C = 280 yards, and B C = 326; how far am I from each of these objects at a station S without the triangle

---

[*] The angle A B D is equal to the observed angle A S C, because they stand on the same arc A D, (Eucl. iii. 21;) for the same reason B A D = B S C.

ABC, where I observed the angle ASC to be $= 25^\circ 42'$, and $BSC = 23^\circ 6'$?

2. The distances between three objects A, B, C, (fig. 10,) are as follows:—$AB = 267$ yards, $AC = 346$, and $BC = 209$; and the angles at a point (S) within the triangle ABC, subtended by those distances, are $128^\circ 40'$, 140°, and $91^\circ 20'$, respectively; what is the distance of the point S from each of the objects?

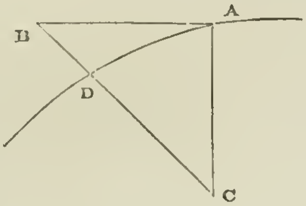
3. If the three objects, A, B, C, as seen from S, be situate as in fig. 12, and AB be $= 122{\cdot}4$ chains, $BC = 73{\cdot}6$ chains, $AC = 81{\cdot}8$ chains, and the angle $S = 22^\circ 44' 40''$. Required the distances SA, SB, and SC?

4. If the three objects, A, B, C, as seen from S, be situate as in fig. 13, and AB be $= 122{\cdot}4$ chains, $BC = 73{\cdot}6$, $AC = 81{\cdot}8$, and the angle $ASC = 110^\circ$. Required the distances SA, SB, SC?

5. If the three objects, A, B, C, as seen from S, be situate as in fig. 11, and AB be $= 2550$ yards, $AC = 7000$ yards, the angles $ASB = 25^\circ 15'$, and $BSC = 35^\circ 30'$. Required the distances SA, SB, SC?

Problem 9.—*To find the distance of the visible horizon*, fig. 14.—*Rule* 1. To the diameter of the earth add the height of the eye, and to the logarithm of the sum add the logarithm of the height of the eye; then will half the sum be the logarithm of the tangent BA, which is nearly the same with the arc DA, the distance required.

Fig. 14.



Rule 2. To half the logarithm of the height of the eye, add 3·8104601, and the sum will be the logarithm of the distance required *in feet*, nearly.

Example.—Let the height of the eye be 100 feet. Required the distance of the visible horizon?

By Rule 1.

Diameter of the earth + 100 = 41,775,460 feet log. 7·6209213
Height of the eye.......... = 100 feet log. 2·0000000

2) 9·6209213
Distance required .... = 64633·9 feet log. 4·8104608

By Rule 2.

Constant logarithm = 3·8104601
Half the logarithm of 100 = 1·0000000

Distance required = 64633·9 = 4·8104601

HEIR, in Law, the person who succeeds another, by descent, to lands, tenements, or hereditaments.

Heir, *Apparent*, is a person so called, in the lifetime of his ancestor, at whose death he is heir at law. *See* Apparent.

Heir *Presumptive*, is one who, if the ancestor should die immediately, would, in the present circumstances of things, be heir: but whose right may be defeated by some nearer heir being born.

Heir *Looms*, in Law, are such goods and personal chattels, as, contrary to the nature of chattels, shall go by special custom to the heir.

HELIACAL, as applied to the rising of a star, planet, &c. denotes its emerging out of the sun's rays, in which it was before hid. When applied to the setting of a star, it denotes the entering or immerging into the sun's rays, and thus becoming lost in the lustre of his beams. A star rises heliacally when, after it has been in conjunction with the sun, and on that account invisible, it gets at such a distance from the sun as to be seen in the morning before the rising of that luminary.

HELIOCENTRIC Place of a Planet, is that place in the ecliptic in which the planet would appear if viewed from the centre of the sun; and consequently the heliocentric place coincides with the longitude of a planet, as viewed from the same centre.

Heliocentric *Latitude of a Planet*, is the inclination of the line drawn between the centre of the sun and the centre of a planet, to the plane of the ecliptic.

HELIOCOMETES, Comet of the Sun, is used to denote a phenomenon which sometimes attends the setting of the sun It is thus denominated by Sturmius, who had observed it, because it seems to make a comet of that luminary, having the appearance of a large tail or column of light which follows the sun at his setting, much in the same manner as the tail of a comet.

HELIOMETER, or Astrometer, is the name given by Bouguer to an instrument which he invented for measuring with particular exactness the diameter of the sun, moon, and planets. This instrument is merely a telescope, consisting of two object glasses, of equal focal distance, placed by the side of each other, so that the same eye-glass serves for both. The tube of this instrument is of a conical form, larger at the upper end, which receives the two object-glasses, than at the lower, which is furnished with an eye-glass and micrometer. Hence two distinct images of an object are formed in the focus of the eye-glass, the distance of which depending upon that of the two object-glasses from one another, may be measured with the greatest accuracy.

HELIOSCOPE, a telescope fitted for viewing the sun without hurting the eyes.

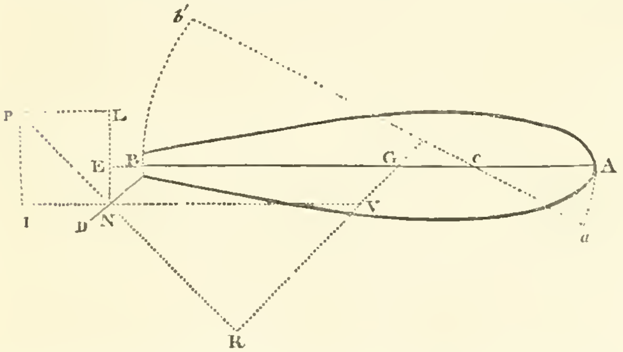
HELIX, in Geometry, the same with *Spiral*, which see.

Helix, in Natural History, the *Snail*, a genus of the vermes testacea class and order. It is used in many parts of Europe as food, particularly at Rome during the weeks of Lent, where they are fattened, and grow to a very large size. *H. Hortensis*, garden-snail, has an imperforate shell, globular, pale, with broad interrupted brown bands; this species inhabits the gardens and orchards in most parts of Europe; it abounds with a viscid slimy juice, which it readily gives out by boiling in milk and water, so as to render them thick and glutinous, and the compound, especially with milk, is reckoned efficacious in consumptive cases. Snails are very destructive to wall fruit: lime and ashes sprinkled on the ground will keep them away, and destroy the young brood. Fruit, already bitten, should not be taken off the tree, for they will not touch the other till they have wholly eaten this, if left for them. The eyes of snails are lodged in their horns, one at the end of each horn, which they can retract at pleasure. Cutting off a snail's head, a little stone appears, which is supposed to be a good diuretic, and excellent in all nephritic disorders.

HELLEBORUS, in Botany, English *hellebore*, a genus of the polyandria polygynia class and order. Natural order of Moltisiliquæ, Renunculaceæ, Jussieu. There are seven species. The root is tuberous. By distillation an extremely poisonous oil is obtained from it.

HELM, a long and flat piece of timber, or an assemblage of several pieces, suspended down the hind part of a ship's sternpost, where it turns upon a kind of hinges to the right or left, serving to direct the course of a vessel, as the tail of a fish guides the body. The helm is usually composed of three parts, *viz.* the rudder, the tiller, and the wheel, except in small vessels, where the wheel is unnecessary. The rudder becomes gradually broader in proportion to its distance from the top, or its depth under water; the back or inner part of it, which joins the stern-post, is diminished into the form of a wedge, throughout its whole length, so as that it may be more easily turned from one side to the other when it makes an obtuse angle with the keel. For a description of the hinges which support it, *see* the articles Googings and Pintles. The length and thickness of the rudder is nearly equal to that of the stern-post. The tiller is a long bar of timber, fixed horizontally in the upper end of the rudder, within the vessel; the movements of the tiller to the right and left accordingly direct the efforts of the rudder to the government of the ship's course, as she advances; which is called steering. The operations of the tiller are guided and assisted by a sort of tackle, communicating with the ship's side, called the tiller-rope, which is usually composed of untarred rope yarns, for the purpose of traversing more readily through the blocks or pulleys. In order to facilitate the management of the helm, the tiller-rope, in all large vessels, is wound about a wheel, which acts upon it with the powers of a windlass; the rope employed in this service being conveyed from the fore-end of the tiller to a single block on each side of the ship, forms a communication with the wheel, by means of two blocks suspended near the mizzen-mast, and two holes immediately above, leading up to the wheel. which is fixed upon an axis on the quarter-deck almost perpendicularly over the fore-end of the tiller. Five turns of the rope are usually wound about the barrel of the wheel, and when the helm is a-midship, the middle turn is nailed to the top of the barrel with a mark, by which the helmsman readily discovers the situation of the helm; the spokes of the wheel generally reach about eight inches beyond the rim or circumference, serving as handles to the person who steers the vessel: as the effect of a lever increases in proportion to the length of its arm, it is evident that the power of the helmsman to turn the wheel will be increased according to the length of the spokes beyond the circumference of the barrel: so that if the helmsman employs a force of thirty pounds, it will produce an effect of from ninety to one hundred and twenty pounds upon the tiller, (the barrel being $\frac{1}{4}$ or $\frac{1}{3}$ of the radius of the spokes,) which again forming the long end of a lever 10 or 15 times the length of its shorter arm, the force of the rudder will by consequence be from 10 times 90 to 15 times 120, or from 900 to 1800 pounds. When the helm operates by itself, the centre of rotation of the ship and her movements, are determined by estimating the force of the rudder by the square of the ship's velocity.

When the helm, instead of lying in a right line with the keel, is turned to one side or the other, as in B D, in the figure, it receives an immediate shock from the water, which glides along the ship's bottom in running *aft* from A to B; and this fluid pushes it towards the opposite side, whilst it is retained in this position: so that the stern, to which the rudder is confined, receives the same impression, and accordingly turns from B to *b* about some point c, whilst the head of the ship passes from A to *a*. It must be observed, that the current of water falls upon the rudder obliquely, and only strikes it with that part of its motion, which acts according to the sine of incidence, pushing it in the direction of N P, with a force which not only depends on the velocity of the ship's course, by which this current of water is produced, but also upon the extent of the sine of incidence. This force is by consequence composed of the square of the velocity with which the ship advances, and the square of the sine of incidence, which will necessarily be greater or smaller according to circumstances; so that if the vessel runs three or four times more swiftly, the absolute shock of the water upon the rudder will be nine or sixteen times stronger under the same incidence: and if the incidence is increased, it will yet be augmented in a greater proportion, because the square of the sine of incidence is more enlarged. This impression, or, what is the same thing, the power of the helm, is always very feeble, when compared with the weight of the vessel; but as it operates with the force of a long lever, its efforts to turn the ship are extremely advantageous. For the helm being applied to a great distance from the centre of gravity G, or from the point about which the vessel turns horizontally, if the direction P N of the impression of the water upon the rudder be prolonged, it is evident that it will pass perpendicularly to R, widely distant from the centre of gravity G; thus the absolute effort of the water is very powerful. It is not therefore surprising, that this machine impresses the ship with a considerable circular movement by pushing the stern from B to *b*, and the head from A to *a*; and even much farther whilo she sails with rapidity, because the effect of the helm always keeps pace with the velocity with which the vessel advances.



Amongst the several angles that the rudder makes with the keel, there is always one position more favourable than any of the others, as it more readily produces the desired effect of turning the ship, in order to change her course. To ascertain this, it must be considered, that if the obliquity of the rudder with the keel is greater than the obtuse angle A B D, so as to diminish that angle, the action of the water upon the rudder will increase, and at the same time oppose the course of the ship in a greater degree; because the angle of incidence will be more open, so as to present a greater surface to the shock of the water, by opposing its passage more perpendicularly. But at that time the direction N P of the effort of the helm upon the ship will pass with a smaller distance from the centre of gravity G towards R, and less approach the perpendicular N L, according to which it is absolutely necessary that the power applied should act with a greater effect to turn the vessel. Thus it is evident that if the obtuse angle A B D is too much enclosed, the greatest impulse of the water will not counterbalance the loss sustained by the distance of the direction N P from N L, or by the great obliquity which is given to the same direction N P of the absolute effort of the helm with the keel A B. If, on the contrary, the angle A B D is too much opened, the direction N P of the force of the action of the helm will become more advantageous to turn the vessel, because it will approach nearer the perpendicular N L; so that the line prolonged from N P will increase the line G R, by removing R to a greater distance from the centre of gravity G, but then the helm will receive the impression of the water too obliquely, for the angle of incidence will be more acute; so that it will only present a small portion of its breadth to the shock of the water, and by consequence will only receive a feeble effort. By this principle it is easy to conceive, that the greatest distance G R from the centre of gravity G, is not sufficient to repair the diminution of force occasioned by the too great obliquity of the shock of the water. Hence we may conclude, that when the water either strikes the helm too directly, or too obliquely, it loses a great deal of the effect it ought to produce. Between the two extremes there is therefore a mean position, which is the most favourable to its operations.

The diagonal N P of the rectangle I L represents the absolute direction of the effort of the water upon the helm. N I expresses the portion of this effort which is opposed to the ship's head-way, or which pushes her astern, in a direction parallel to the keel. It is easily perceived that this part N I of the whole power of the helm contributes but little to the turn of the vessel; for, if I N is prolonged, it appears that its direction approaches to a very small distance G V from the centre of gravity G; and that the arm of the lever B N=G V, to which the force is applied, is not in the whole more than equal to half the breadth of the rudder: but the relative force N L, which acts perpendicular to the keel, is extremely different. If the first N I is almost useless, and even pernicious, by retarding the velocity; the second N L is capable of a very great effect, because it operates at a considerable distance from the centre of gravity G of the ship, and acts upon the arm of a lever G E, which is very long. Thus it appears, that between the effects N L and N I, which result from the absolute effort N P, there is one which always opposes the ship's course, and contributes little to her motion of turning; whilst the other produces only this movement of rotation, without operating to retard her velocity.

Geometricians have determined the most advantageous angle made by the helm with the line prolonged from the keel, and fixed it at 54° 44′, presuming that the ship is as narrow at her floating-line, or at the line described by the surface of the water round her bottom, as at the keel. But as this supposition is absolutely false, in as much as all vessels augment their breadth from the keel upward to the extreme breadth, where the floating-line or the highest water-line is terminated; it follows that this angle is too large by a certain number of degrees. For the rudder is impressed by the water, at the height of the floating-line, more directly than at the keel, because the fluid exactly follows the horizontal outlines of the bottom; so,that a particular position of the helm might be supposed necessary for each different incidence which it encounters from the keel upwards. But as a middle position may be taken between all these points, it will be sufficient to consider the angle formed by the sides of the ship, and her axis or the middle line of her length, at the surface of the water, in order to determine afterwards the mean point, and the mean angle of incidence.

It is evident that the angle 54° 44′ is too open, and very unfavourable to the ship's head-way, because the water acts upon the rudder there with too great a sine of incidence, as being equal to that of the angle which it makes with the line prolonged from the keel below: but above the shock of the water is almost perpendicular to the rudder, because of the breadth of the bottom, as we have already remarked. If then the rudder is only opposed to the fluid, by making an angle of 45° with the line prolonged from the keel, the impression, by becoming weaker, will be less opposed to the ship's head-way, and the direction N P of the absolute effort of the water upon the helm drawing nearer to the lateral perpendicular, will be placed more advantageously, for the reasons above mentioned. On the other hand, experience daily testifies, that a ship steers well when the rudder makes the angle D B equal to 35° only.

It has been already remarked, that the effect of moving the wheel to govern the helm increases in proportion to the length of the spokes; and so great is the power of the wheel, that if the helmsman employs a force upon its spokes equivalent to 30 pounds, it will produce an effect of 90 or 120 pounds upon the tiller. On the contrary, the action of the water is collected into the middle of the breadth of the rudder, which is very narrow in comparison with the length of the tiller; so the effort of the water is very little removed from the fulcrum B upon which it turns; whereas the tiller forms the arm a lever 10 or 15 times longer, which also increases the power of the helmsman in the same proportion that the tiller bears to the lever, upon which the impulse of the water is directed. This force then is by consequence 10 or 15 times stronger; and the effort of 30 pounds, which at first gave the helmsman a power equal to 90 or 120 pounds, becomes accumulated to one of 900 or 1800 pounds upon the rudder. This advantage then arises from the shortness of the lever upon which the action of the water is impressed, and the great comparative length of the tiller, or lever, by which the rudder is governed; together with the additional power of the wheel that directs the movements of the tiller, and still farther accumulates the power of the helmsman over it. Such a demonstration ought to remove the surprise with which the prodigious effect of the helm is sometimes considered from an inattention to its mechanism; for we need only to observe the pressure of the water, which acts at a great distance from the centre of gravity G, about which the ship is supposed to turn, and we shall easily perceive the difference there is between the effort of the water against the helmsman, and the effect of the same impulse against the vessel. With regard to the person who steers, the water acts only with the arm of a very short lever N B, of which B is the fulcrum: on the contrary, with regard to the ship, the force of the water is impressed in the direction N P, which passes to a great distance from G, and acts upon a very long lever E G, which renders the action of the rudder extremely powerful in turning the vessel; so that, in a large ship, the rudder receives a shock from the water of 2700 or 2800 pounds, which is frequently the case when she sails at the rate of three or four leagues by the hour; and this force being applied in E, perhaps 100 or 110 feet distant from the centre of gravity G, will operate upon the ship, to turn her about, with 270,000 or 308,000 pounds; whilst, in the latter case, the helmsman acts with an effort which exceeds not 30 pounds upon the spokes of the wheel.

After what has been said of the helm, it is easy to judge, that the more a ship increases her velocity with regard to the sea, the more powerful will be the effect of the rudder; because it acts against the water with a force, which increases as the square of the swiftness of the fluid, whether the ship advances or retreats, or, in other words, whether she has head-way or stern-way; with this distinction, that in these two circumstances the effects will be contrary. For if the vessel retreats, or moves astern, the helm will be impressed from I to N; and instead of being pushed, according to N P, it will receive the effort of the water from N towards R; so that the stern will be transported to the same movement, and the head turned in a contrary direction.

HELMET, an ancient defensive armour, worn by horsemen both in war and in tournaments, which covered both the head and face, leaving only an aperture in the front secured by bars which was called the visor. It is still used in heraldry by way of crest over the shield or coat of arms, to express the different degrees of nobility by the different manner in which it is borne. Thus, a helmet in profile is given to gentlemen and esquires; to a knight the helmet standing forward and the beaver a little open; the helmet in profile and open, with bars, belongs to all noblemen under the degree of a duke: and the helmet forward and open, with many bars, is assigned to kings, princes, and dukes.

HEMISPHERE, in Geometry, is one-half of a globe or sphere, formed by a plane passing through its centre.

Hemisphere, in Astronomy, is particularly used to denote one-half of the sphere, as separated by the plane of the equator; that situated towards the north pole being called the northern, and the other the southern hemisphere. The horizon also divides the sphere into two hemispheres, the lower and the upper; the latter being that half which has the zenith for its vertex, the former having the nadir in its vertex.

We have, in this work, given two hemispheres of the celestial regions, exhibiting all the stars and constellations exactly as they appear in nature: the whole of the stars having their right ascension and declination computed for the present century.

Hemisphere is also used for a map or projection of half the terrestrial globe, or half the celestial sphere on a plane. These are also frequently called *Planispheres*.

HEMISTICH, in poetry, denotes half a verse, or a verse not completed.

HEMP. *See* Cannabis. The cannabis sativa, or hemp plant, is cultivated on account of its external filaments, which constitute the hemp used for cordage, canvass, cloth, &c. and the seeds abound with oil. The operations of harling, watering, breaking, swingling, and heckling hemp are very much like those practised in the dressing of flax.—The hemp imported into this country chiefly comes from Russia. The best hemp should be clean, soft, tender, of long staple, and a sound palish-yellow colour, neither green nor red. Many experiments have been made upon the relative strength and utility of the nettle, the hop, the aloe, the yucca, the barks of the mulberry and bread-fruit tree, and many other vegetable fibres for the production of thread, cloth, and paper, yet is the hemp, the flax, and the cotton superior to them all, not only on account of their abundance and easy culture, but from the very superior strength and fineness of their fibres under all changes of circumstance.

The hemp being the larger and stronger plant, yields the longest, coarsest, and strongest fibres, and is usually employed in forming all kinds of ropes and cordage, coarse cloth and sacking; notwithstanding which, if properly dressed and managed, a white linen may be produced from it very little inferior in texture to that of flax, and certainly superior in durability. Flax, on the contrary, being a more tender and delicate plant, produces a finer fibre by ordinary treatment, and is used for the finer fabrics of thread, linen, and cambric.

The flax plant (*Linum* of Linnæus) is an annual, requiring to be sown with seeds of the last year's product, from the second week in March to the middle of April. It prefers a free open loam, which is neither subject to too much wet or drought; is certain of producing a good crop on new ground, and will generally thrive on any soil which is proper for barley or oats. It remains in the ground till the end of July, or middle of August, when it ripens, and is fit for pulling,* (unless it should, from circumstances, be desirable to keep it for seed only,) and may be succeeded by a crop of wheat or turnips, for which it is an excellent preparation. It may also be sown to advantage with clover seeds, which will then succeed it as an after-crop. Hemp *(Cannabis sativa)* is a much more rank and coarse plant, growing from six to sixteen feet in height, and is more or less common in all countries. It is, however, chiefly cultivated in the northern parts of Europe, whence it is largely imported into England. It thrives well in England; and English hemp, when properly manufactured, is found more compact, strong, and durable than that of Russia. It should be sown about the same time as flax, in a deep, rich, and moist soil, on which account the Isle of Ely and the fens of Lincolnshire are particularly favourable to its growth. Like flax, when sufficiently ripe, it is not cut, but pulled up root and all, on which account both these plants leave the soil particularly clean.

---

* This should be done soon after the bloom falls off, when the stalk begins to turn yellow, and before the leaves fall off.

The fibre is situated between the interior wood and exterior bark of each stalk, and was till lately, always obtained by an aqueous decomposition, or by rotting away the wood and exterior bark by exposure to moisture, since the fibre itself (though, no doubt, somewhat injured by the process) has sufficient strength and durability to withstand it in a great measure. The process of rotting away the woody from the fibrous parts of plants, though one of extreme antiquity, has proved extremely detrimental to the health, not only of the inhabitants, but injurious to the cattle, of those countries in which it is carried on to a considerable degree. It becomes the source of many pestilential diseases, among which perhaps the Malaria, so prevalent in the vicinity of Rome and Naples, may be numbered; besides which, since flax and hemp ripen about the month of August, and require to be submitted to this process as soon as they are taken from the ground, or at least before they dry, the farmer's attention becomes necessary to them when his time is most valuable and can least be spared, namely, in the time of, or immediately antecedent to, his corn harvest.

The product to be expected from the growth of flax is of two kinds, viz. The seed for oil and sowing, and the fibre for spinning. These are nearly equal in value, and it has been usual for cultivators to govern their operations by the kind of crop which is produced; thus, if it grows short and branchy, the seed will be more valuable than the flax, which consequently should not be disturbed until that seed is perfectly ripe; while, on the contrary, if it proves tall, and has not fallen, the seed (although not ripe) is excellent food for cattle, and must be threshed out as perfectly as possible, and the remainder sacrificed to the fibre. A very good machine for threshing out flax in this state, was invented by Mr. Cleall, and will be found described in the Transactions of the Society for the Encouragement of Arts and Sciences, London, vol. xxv. p. 143.

The operation of rotting, or, as it is generally called, Water Retting Flax and Hemp, is one of considerable nicety, and hazard to the cultivator, on which account it has, in all probability, proved a much greater barrier to the cultivation of these useful plants in England, than the alleged exhaustion of soil, or any other cause; for its perfection, and the period when it should cease, depend on several fortuitous circumstances, which may dispose the woody matter of the stem to decompose with greater or less facility. Thus it will be influenced by the strength and vigour of the plant, the moisture or dryness of the season, the temperature of the air during the process, as well as the soil from which the plant is produced. If the operation is carried too far, not only the woody matter, but the fibre also, will be destroyed or injured, and if not far enough, it has generally been thought that the flax will not dress: and thus, after a good crop has been produced, it may be much injured, if not spoiled, in the incipient stage of its manufacture.

The steeping or watering of flax is most commonly performed in artificial ponds or canals, excavated by the sides of rivers, and generally about 40 feet long, 6 feet wide, and 4 deep, a sufficient size to admit the produce of an acre of land at once. Sluices are so disposed, that the contained water may at any time be let off, and a fresh quantity of water, which should be soft, admitted. These canals should be exposed to the sun, which assists the decomposition. The fresh-gathered flax being tied in bundles or handfuls, is carefully placed in these reservoirs, the superior bundles causing those which were first deposited to sink; and in this way each reservoir is filled, but not to such a degree as to force any part of the flax to touch the bottom; and when filled, the whole surface is covered with close hurdles or boards, and sufficiently loaded with stones to cause every part of the flax to be under the surface of the water. In this state it is left, and occasionally examined, to ascertain how far the process of decomposition is completed, which will generally be within a fortnight. The bundles of flax, which have by this time become very tender and difficult to handle, are now to be taken out on boards or trays, and removed on to the nearest short grass or heath, where they are regularly disposed in rows to loose their moisture, and in which situation they receive an additional preparation from the evening dews and occasional showers completing the decomposition, and at the same time washing away the slime and mucilage with which they are mixed. This last exposure is called dew-retting, and continues, according to the state of the atmosphere, for four or five weeks, or until the flax is as dry as it can be got, of a clear good colour, and all the woody matter which remains is perfectly brittle. The fibre will still retain most of its original tenacity, if the operation has been carefully and skilfully conducted. It is then carried away, like hay, on a fine dry day, and deposited in barns, being now ready for the next process, called breaking and dressing.

So soon as a reservoir is emptied as above described, its water is let off, of course in a very putrid and unwholesome state. The basin is washed out; a new quantity of water is admitted, which is now ready to receive a fresh charge of flax. The rivers, by receiving this water, particularly if hemp has been steeped in it, become contaminated; their fish are killed; the cattle refuse to drink it; and the atmosphere around is filled with noxious vapours, most detrimental to the health of the inhabitants.

The breaking of flax is the separation of what is technically called *the Boon*, or woody matter, from *the Harle*, or useful fibre; and this may be effected in a variety of ways. It is done in mills by machinery, and by hand, and in almost all cases is very effectually performed by a set of blunt iron teeth or breakers, fixed upon one piece of wood, and met by another similar set of teeth fixed to a moveable piece, which is worked by the one hand, while the flax in handfuls is introduced between these teeth in various directions with the other hand. This breaks and knocks off the greater part of the wood in small fragments, called chaff, and the operation is completed by *scutching* or beating the flax against a smooth post called a scutching post, and also beating it with an instrument somewhat resembling a curry-comb, and called a hand scutch, by which the few remaining fragments of wood or boon are taken away, and nothing but the long fibre remains, which is now to be hackled, or drawn by the hand over a species of comb, having a great number of very sharp long and perpendicular steel points upon it, by which any remaining boon and the short fibres or tow are removed, and the long fibres which remain are regularly disposed, and ready to pass into the hands of the spinner.

Flax and hemp have obtained the character of being very impoverishing crops to the land which bears them, and very deservedly so. For while every other crop makes a return to the land, either of its roots or branches to decay, and forms manure, or becomes matter of animal food; these make no such return, at least to their own land.

But although the above methods are still practised on the continent, it has been discovered, that the process of steeping and dew retting, as applied to flax and hemp, is wholly unnecessary; and that these vegetables will not only dress, but will produce an equal, if not greater quantity of more durable and serviceable fibre, when treated in the dry way, than when exposed to the tedious, difficult, and precarious process which has been above described; and it is to be lamented, that a discovery of so much national importance, made in this country, should not hitherto have been recorded and described in any of her journals or archives of science.

This discovery was first given to the world by Jas. Lee, Esq. formerly of Old Ford, in Essex, and latterly of Merton Abbey

Flax Mills, he having obtained a patent for his process in 1812, under the singular protection of a special act of Parliament, which permitted the specification of that patent invention to remain sealed up for seven years, contrary to the general practice in such cases.

Among the more valuable concomitants of this discovery, are the circumstances of the noxious vapours and unhealthy employment attendant upon the former process of steeping flax being removed, as well as the supply of an abundance of in-door winter employment, being produced in the breaking and preparation of flax for spinning, when it has been thus husbanded, and which may be resorted to at all convenient times, when the farming labourers and servants are shut out from other work by the inclemency of seasons or other causes; and thus it is presumed a new source of active and lucrative employment is held out to the British farmer, by the adoption of which, he may in a few years be in the receipt of that immense capital which is now paid to foreign countries upon the importation of flax and hemp.

The machinery to be used for breaking and manufacturing the flax and hemp prepared by his dry method, so far as it has come before the public in the use of Mr. Lee's patent process, does not appear to have fully answered his purpose; for we find that a few years since he obtained another patent for other machinery and processes not included in the first, and of which the specification is not protected by the same secrecy of enrolment. He thus appears to have been made fully satisfied, by experience, of the incapacity of his first machines to produce much work, and therefore now abandons them, and performs his whole operation by means of a series of small iron fluted rollers, combined by pairs in frame-work, working in each other's teeth or projections, (as shewn in the plate of Mills,) and made to press or bear upon each other in any assigned degree, and so as to admit larger or smaller charges of flax between them, by means of levers and weights; and although the application of such fluted rollers to the breaking of flax and hemp has long been common, particularly in Scotland, yet Mr. Lee's arrangement of them is novel, ingenious, and perfectly answers the purpose.

Instead of using one or two pair, as usual, he proposes to dispose a number of single pairs of rollers by the side of each other, having them all kept in motion at once by a water wheel or other prime mover; and instead of passing the flax through them in its natural straight form, it is entered between them, and as soon as the ends appear, and come out on the opposite side of the rollers, those ends which are following are intermixed or overlayed, or, as it is technically called, *tailed on* to the first, so as to form a circular hoop or skein of flax, which having, as it were, no end, will continue to revolve between the rollers for any length of time.

The importance of a cheap, effective, and expeditious mode of breaking and preparing raw flax and hemp, is such, that it cannot be a matter of surprise, that many ingenious mechanics should have turned their attention to this subject. Several models of machines for this purpose have been invented, particularly by Bond and Durand, which will be found described in the Transactions of the Society for the Encouragement of Arts, Manufactures, and Commerce, vol. 25, p. 152, and vol. 31, p. 269; and especially those of Messrs. Hill and Bundy, of Camden Town, London, for which Mr. Bundy obtained a patent for Great Britain and France, and which, from the novelty of their actions and motions, and the very speedy and efficacious manner in which they perform their work, deserve to be particularly noticed.

These machines are, a Breaker and a Rubber.—The first being for the purpose of separating the harle from the boon, as usual, but by a new process: the latter for rubbing and subdividing the fibres so as to produce it in its greatest state of perfection, and finally cleansing it before it goes to the hackler. The breaking machine will be first described, as it is to be first used, and it will appear, that although it consists chiefly of fluted or toothed cylinders, yet it varies from all other machines for the same purpose, which have preceded it, by the inequality of the depth of its teeth, the play or space which exists between one tooth and another, and in the reciprocating motion of the cylinders combined with their progressive motion, instead of its being progressive only, as in all former cases; by these means the happiest effects are produced. The simple manner in which this complex motion is brought about, reflects the highest credit on the mechanical skill of Mr. Bundy, the inventor, not only of these machines, but of many others of equal ingenuity.

Fig. 1.

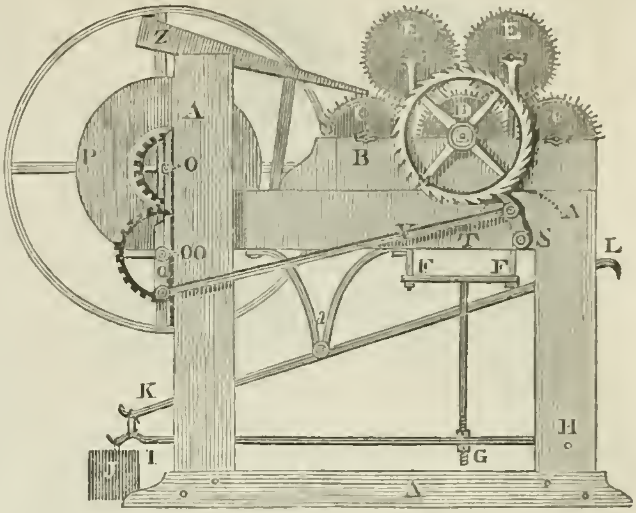
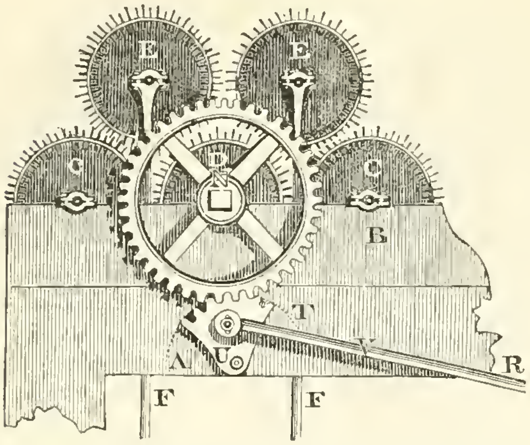


Fig. 1 represents a side view of the breaking machine on a scale of about half an inch to a foot. The framing, A, is of timber, which serves to support the five breaking cylinders marked C c D E E, turning on pivots. C D and c move in brass bearings, fixed upon the boards or supports B, on the two opposite sides of the machine, while E E merely lay above and between C D and D c, and are drawn down to these by two rods, as seen at F F. The lower ends of these are joined by a connecting bar, and another rod proceeds downwards, its lower end being fixed by a double adjusting nut G, near the pin or fulcrum H, of the lever or presser, H, I, which is loaded with a weight J. There is a similar lever on each side of the machine, to bear down the four ends or pivots of the two rollers E E, and the ends of these levers nearest I, are united with a cross bar, by means of which one weight, J, acts on them both, and is made to press equally by an adjusting nut and screw, on each side, like G. K L is a lever placed under the machine, one end of which is attached to the weight J, in such manner that by pressing down its end L, J is raised, and all pressure is instantly prevented between the superior cylinders E E, and those under them at C D c, for stopping the operation of the machine at any time. The breaking cylinders are about eighteen or twenty inches in length, and are made of beech or any hard wood, and are all similar to each other in dimensions, and in having breakers which act also as teeth, extending like projecting plates their whole length parallel to the axis. These breakers or teeth are formed of thin hoop-iron, let about half its width into saw cuts in the cylinders into which they are driven, and they are retained in their places by iron hoops put on to each end of the cylinders; they are about half an inch asunder, their external edges are well rounded, so as not to cut the flax, and they are alternately long and short; the long or deep teeth projecting about three-quarters of an inch from the cylinder, while the short ones are about half that length. In placing the lower breaking cylinders in their places, care must be taken that they do not touch each other, since their teeth are only to connect through the medium of the two upper rollers which press upon them. The axis of the roller D is longer than the others, and extends on both sides beyond the frame and upon each end of it is fixed a cast-iron wheel, by which motion is to be given to this cylinder, and through this to all the others. Both the wheels are of the same diameter, but one is a ratchet wheel, as will be seen in the last figure, while that on the opposite side is a spur or common toothed wheel, as will be seen in fig. 2, which represents such parts of the machine on the opposite side as are essential to its motion, and the same letters of reference are used in both figures to denote similar parts.

Fig. 2.

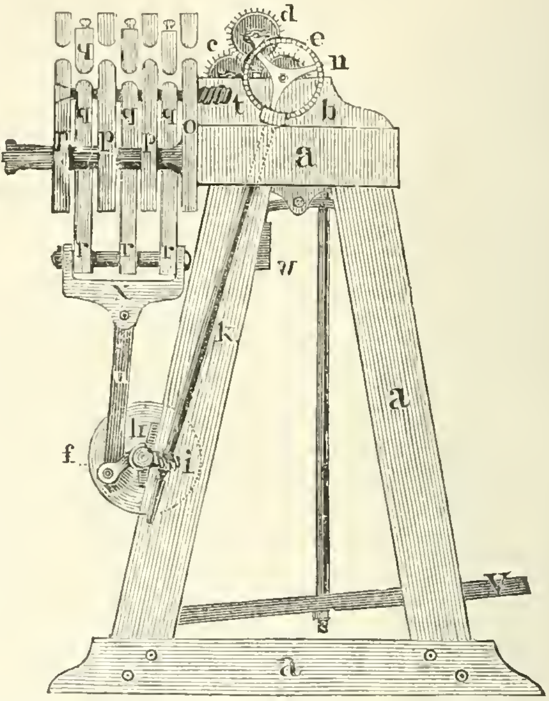


The first motion is given to this machine from the iron spindle O, fig. 1, which may be turned by a handle, or by a band and rigger, as at P. It may also be connected with a pair of spur wheels and a fly, as shewn in fig. 1, to assist its motion. On each end of the lower spindle, if two are used, there is a crank, as at Q, attached to a connecting rod V, the opposite end of which in fig. 1, is attached to a pall or lever turning on a centre S, so that when O, or O O, is turned, the end of this lever will describe a portion of a circle, shewn by the dotted line T A, and will engage with the ratchet teeth of the wheel M, and carry it partly round; while on the other side of the machine, shewn in fig. 2, the connecting rod V passes from the crank of O to a toothed segment U, the teeth of which work into the teeth of the spur wheel N, fixed upon the opposite gudgeon of the breaking cylinder D. The connecting rod on this side of the machine must be so adjusted in length, that in its motion outwards the end tooth of U, next to A, must be withdrawn out of the teeth of the wheel N, but that when it moves in a contrary direction, or from T towards A, it must move completely in the teeth of the wheel, and not leave them, and of course N at this time is incapable of any other motion, but what the segment U also has.

The connecting rod Q V, in fig. 1, must also be so adjusted in length to the pall or gathering tooth S, as to make it continue to act upon its wheel M, for the space of one tooth of N in fig. 2, after the segment U has been withdrawn from its wheel, N; and thus, although the motion of U would produce a backward and forward motion of its corresponding wheel N, and the breaking cylinder D, and consequently of all the other cylinders, yet by the after action of S upon M, the roller D and its wheel N are made to advance gradually by the space of one tooth of N for every revolution of O; and thus a slow but regular progressive motion of the cylinders is obtained at the same time that the vibratory or oscillating motion is going on. The flax is fed or supplied by placing it in handfuls on the feeding trough Z, and pressing it gently between the rollers, C and E, and it is delivered out from between the rollers E and e, at the end of the machine next to L, in a sufficiently clean and divided state to enter the rubbing machine, which will be next described. The superiority of this machine over common fluted rollers needs no comment, since the distance between the teeth and the shake which is produced by the alternating motion of the cylinders exactly gives that action which is best suited to break off and disengage the bark and woody matter, which, when dry, is quite brittle, and falls to the bottom of the machine. Once passing the rollers is in general sufficient for either flax or hemp stalks, but the work is rendered more perfect by a second passage through them, which does not at all injure the fibre.

The rubbing machine, which is to be used immediately after the above breaking process, was suggested to the inventor from the beneficial effect which he found produced on broken flax by rubbing it between the hands in the same manner that linen is rubbed while washing, and which not only cleanses it of the small fragments of wood and bark which adhere to it, but likewise opens and subdivides the fibres, so as to make them produce the finest thread. The machine and operation are altogether new as applied to flax and hemp, and it is confidently hoped considerable benefit may arise from their use. Fig. 3 represents a side view, or rather section of this machine, drawn on a scale of one inch to a foot.

Fig. 3.



In this, *a* is the wooden frame for supporting the machine; *b*, the bearers for the three rollers *c d e*, disposed as in the breaking machine; but in this case, they are only for the purpose of drawing or leading the flax through the machine, (the breaking being presumed to have been already done by the last described, or any other process;) they must be fluted or grooved, or may be made in the same manner as the breaking cylinders, but with the teeth of equal length, much shorter, and of a finer gauge or pitch; *f* is a rigger or pulley to which a rapid circular motion is to be given; it is hung on a shaft or spindle turning in brass bearings, and fixed to the frame *a*; on the end *h* of this spindle is formed an endless screw or worm, which turns a small wheel *i* fixed upon the lower end of an iron spindle *k* turning in bearings, and leading by a bevil pinion at its upper end to the face wheel *n*, which is fixed on to one of the gudgeons of the fluted or toothed roller *e*, so that whenever the rigger *f* is turned, even with a rapid motion, a very slow motion will be communicated to the rollers *c d e* The most essential part of this machine consists of the rubber boards *o p q r*, which are placed at the front of the machine are seven in number in the print, but may be more or less, and are about an inch in thickness; they may be made of beech, oak, or any moderately hard wood. Their edges or sections can only be seen in this representation, but their length may be from eight inches to a foot or more. The board *o* is firmly fixed to the top of the framing *a*, and is without motion, while those marked *p p p* are supported upon the two strong cylindrical iron pins *s*, which are firmly screwed into the frame *a*, and pass through holes which fit them in the boards *p p p*, so that these last can be moved to a greater or less distance from each other, but are incapable of up and down motion. The intermediate boards *q q q* are so much shorter as to pass between the iron pins *s* and admit of an up and down motion between *p p p;* for this purpose, they are all connected together by an iron link or staple *x*, fixed upon the top of the connecting rod *u*, the lower end of which works upon a crank in the middle of the first spindle upon which the rigger *f* is placed, so that in every revolution of *f* the moveable boards *q q q* are driven upwards and downwards between the more stationary boards *p p p*, and the one which is fixed at *o*. The whole of the boards are drawn towards *o* by means of a rod on each of their sides passing through *p p p* and *o*, and acted upon at *t* by weights or spiral wire springs, and the whole of the boards are perforated with a slit or mouth from four to six inches long, (according to their width) and about a quarter of an inch wide, placed near their tops at an equal distance from the top of each, and nicely rounded off on all its edges. The consequence will be, that whenever the crank is in an horizontal situation, all these slits will coincide, but when the crank is down, as in the figure, the slits in *q q q* (which slits are seen only in section) will be below those in *p p p* and *o*, while when the crank is up they will be elevated above them; and thus it will easily be perceived, that if flax, or any other flexible material, is passed through the slits in the boards when they do coincide, and then conducted between the toothed rollers, that while these draw it slowly on through the machine, the boards *p p*, *q q*, &c. by their rapid up and down motion, will effectually rub it, and cleanse it from any extraneous matter which may adhere to it, as well as open the fibres; and for the better regulation of this operation, *v* is a treadle or lever near the foot of the attendant, by pressing on which, the weight *w*, which depresses the top roller *d*, will be raised, in consequence of which the rollers will cease to draw, although the rubbing still continues, so that its velocity in passing the machine may be correctly regulated at the will of the superintendant.*

The average crop which has been produced in England from sowing three bushels of flax or lint seed on an acre of land, is 2¼ tons of flax stem, which, when broken and prepared, yields from 10 to 13 cwt. of harle, or flax fit for hackling, and the boon or woody matter which falls through the machine, will yield from 90 to 100 bushels of chaff from the seed, and is fit for provender for horses or cattle, and from 35 to 40 cwt. of chaff from the stem, making a valuable manure, while from 10 to 14 bushels of seed may, in almost all cases, be procured from the same quantity. The operation of hackling, which succeeds that of breaking, was here minutely described and shewn, and by this the average of 12 cwt. of harle, produced by an acre of land, becomes diminished down to about from 450 to 380 lbs. of fine long flax, fit for spinning the best materials, being but little more than 1/11th of the gross produce; notwithstanding which, the value of the seed, the chaff, and the tow, which is the refuse of the hackling process, are said to amply compensate for this apparent loss.

Spinning is the operation which succeeds to hackling, and the advantages arising from this union, by twisting the fibres together, was detailed, as well as the mechanical action, by which strength and continuity of length are obtained by the lateral friction of one fibre against another.

The yarns, when completed, are wound into skeins of 300 yards each in length, by means of counting reels, which strike upon a bell, or otherwise indicate when this quantity is complete, and such skeins are called *leas.* From the number of leas which a pound of flax will produce, its denomination and value is computed. Thus yarn No. 10, or 10 lea yarn, is ten times 300 yards, or 3000 yards from one pound of hackled flax; 40 lea yarn, or 12,000 yards from the pound, is said to be the finest produced in England by machine spinning, though by hand spinning the process has been carried as high as 120 leas to the pound. The average work of every spindle in a spinning mill, where thousands are usually in motion at once, is estimated at an average of 12 leas in the day, or 3600 yards; and in spinning the finest yarns the spindle is said to revolve 3000 times in a minute! We do not, however, vouch for this almost incredible velocity, not having had an opportunity of calculating the machinery.

The qualities of the tow, or refuse of flax and hemp, and the various operations performed upon it, cannot here be enumerated and explained, among which is that of carding it by machinery, so as to produce useful rovings for spinning inferior yarns.

HENDECAGON, in Geometry, a figure that has eleven sides, and as many angles.

HEPATIC GAS, the old name for sulphuretted hydrogen.

HEPTACHORD, in the ancient poetry, signified verses that were sung or played on seven chords, that is, on seven different notes.

HEPTAGON, in Geometry, a figure consisting of seven sides and as many angles.

HEPTARCHY, a government of seven persons; also a state or country divided into seven kingdoms, and governed by seven independent princes. England was at one period divided into seven kingdoms, under the Saxons, hence called the Saxon Heptarchy.

HERALD, is an officer at arms, whose business it is to denounce war, proclaim peace, or be otherwise employed by the king in martial messages or other business.

Heralds are the judges and examiners of gentlemen's coats of arms, and preservers of genealogies, and they marshal all solemnities at the coronation of princes, and funerals of great persons.

HERALDS. The heralds, which are six in number, are distinguished by the names of Richmond, Lancaster, Chester, Windsor, Somerset, and York, and are all equal in degree, only preceding according to the seniority of their creation, their patents being under the great seal of England.

HERALDRY, is a science which teaches how to blazon or explain, in proper terms, all that belongs to arms; and how to marshal, or dispose with regularity, divers arms on a field. It also teaches whatever relates to the marshalling of solemn processions, and other public ceremonies at coronations, installation of knights, creations of peers, nuptials, christenings of princes, funerals, &c.

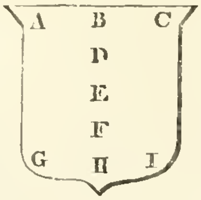
Arms, sometimes called *coats of arms*, are hereditary marks of honour, made up of fixed and determined colours and figures, granted by sovereign princes, as a reward for military valour, or some signal public service: and serve to denote the descent and alliance of the bearer; or to distinguish states, cities, societies, &c. civil, ecclesiastical, and military. Arms are distinguished by different names to denote the causes of their bearing, such as *arms* of *dominion*, of *pretension*, of *concession*, of *community*, of *patronage*, of *family*, *of alliance*, of *succession*, of *assumption*. Those of dominion and sovereignty are those which emperors, kings, and sovereign states constantly bear; being, as it were, annexed to the territories, kingdoms, and provinces they possess. Thus, there are the arms of England, of France, &c.

Arms of *pretension* are those of such kingdoms, provinces, or territories, to which a prince or lord has some claim, and which he adds to his own, although such kingdoms or territories are possessed by another prince or lord. Arms of *concession*, or augmentation of honour, are entire arms, as the fortress of Gibraltar on the escutcheon of Lord Heathfield. Arms of *community* belong to bishoprics, cities, companies, &c. Of *patronage*, to governors of provinces, lords of manors, &c. Arms of *family* are the property of individuals, and it is criminal in any persons not of the family to assume them. Arms of *alliance* shew the union of families and individuals. Arms of *succession* are taken up by those who inherit certain estates, manors, &c. either by will, *entail*, or *donation*, and which they impale or quarter with their own; this multiplies the titles of some families from necessity, and not from *ostentation.* Of *assumption*, or assumptive arms, are taken up by the caprice or fancy of upstarts of mean extraction, who, on becoming persons of fortune, assume them without a legal title. They are also such as a man of his proper right may assume, with the approbation of his sovereign and of the king of arms.

---

* For an account of the quantity of work these machines are capable of performing, and other particulars respecting them, see the Report of the Select Committee of the House of Commons on the subject. Mr. Buody has likewise invented a very ingenious machine for hackling flax.

The parts of arms are the *escutcheon*, the tinctures, charges, and *ornaments*. Heralds distinguish nine different points in escutcheons, in order to determine exactly the positions of the bearing they are charged with, as in the figure. A, the dexter chief; B, precise middle chief; C, sinister chief; D, honour point; E, fess point; F, nombril point; G, dexter base; H, precise middle base; I, sinister base.



The *tinctures* mean that variable hue common both to the shields and their bearings; and there are seven tinctures, *yellow* or *gold*, expressed by *dots*, *white*, or *argent*; *red* by *perpendicular* lines: blue or *azure* by *horizontal* lines. *Purple*, by diagonal lines from *right* to left; *green*, by the same from *left* to right; black by horizontal and perpendicular lines crossing; and orange and blood colour are expressed by diagonal lines crossing each other.

The charges are those emblems occupying the field of the escutcheon, or any part of it. All charges are distinguished by the name of honourable ordinaries, sub-ordinaries, and common charges.

Honourable ordinaries, the principal charges in heraldry, are made of lines only, which, according to their disposition and form, receive different names. Sub-ordinaries are ancient heraldic figures frequently used in coats of arms, and which are distinguished by terms appropriated to each of them. Common *charges* are composed of natural, artificial, and even imaginary things, such as stars, animals, trees, ships, &c.

The ornaments that accompany or surround escutcheons, were introduced to denote the birth, dignity, or office of the person to whom the arms appertain; they are used both by clergy and laity. Those most in use are of ten sorts, *viz.* crowns, coronets, mitres, helmets, mantlings, chapeaux, wreaths, crests, scrolls, and supporters.

The *crest* is the highest part of the ornaments of a coat of arms; it is called crest from the Latin word *crista*, which signifies a comb, or tuft, such as many birds have upon their heads, as the peacock, &c. Crests were anciently marks of great honour, because they were worn only by heroes of great valour and high rank, that they might be the better distinguished in an engagement, and thereby rally their men if dispersed. They are at present considered as mere ornaments.

The *scroll* is an ornament usually placed below the shield and supporters, containing a motto or short sentence, alluding thereto, or to the bearing, or to the bearer's name.

It is not our object to dwell on this article, and we will therefore conclude it by noticing briefly that the science of heraldry consists in blazoning and marshalling arms. The word *blazoning* is borrowed from the French *emblazoner*; and signifies displaying or explaining the several emblems and colours of an achievment in proper terms.

The blazoning of the arms of gentlemen, esquires, knights, and baronets, is derived from metals and colours; those of barons, viscounts, earls, marquises, and dukes, from precious stones; and those of princes, kings, and emperors, from the planets.

Marshalling is the orderly disposition of several coats of arms, belonging originally to different families, within one shield or escutheon, together with all the proper armorial ensigns, ornaments, and decorations. We will in this place *first* notice the four great orders of British knighthood; *secondly*, we will explain the various heraldic terms.

Degrees of Precedency, and different kinds of Arms.

The King.
Princes of the Blood.
Archbp. of Canterbury.
Lord High Chancellor.
Archbishop of York.
Lord Treasurer.
Lord President of the Council.
Lord Privy Seal.
Dukes.
Eldest sons of Dukes of the Blood Royal.
Marquises.
Eldest sons of Dukes.
Earls.
Marquises' eldest sons.
Duke's younger sons.
Viscounts.
Earl's eldest sons.
Marquises' younger sons.
Bishops.
Barons.
Speaker of the House of Commons.

Degrees of Precedency, and different kinds of Arms

Lord Commissioner of the Great Seal.
Viscounts' eldest sons.
Earls' younger sons.
Barons eldest sons.
Privy Counsellors not Peers.
Chancellor of the Exchequer.
Chancellor of the Duchy.
The Knights of the Garter not Peers.
The Lord Chief Justice of the King's Bench.
The Master of the Rolls
The Lord Chief Justice of the Common Pleas
The Lord Chief Baron of the Exchequer.
Puisne Judges and Barons.
Knights Banneret, if made in the field of battle.
Master in Chancery,
Viscounts' younger sons.
Barons' younger sons.
Baronets.
Knights Banneret.
Knights of the Bath.
Knights Bachelors.
Baronets' eldest sons.
Knights' eldest sons.
Baronets' younger sons.
Knights' younger sons.
Field and Flag officers.
Doctors graduate.
Serjeants at Law.
Esquires.
Gentlemen.
Yeomen.
Tradesmen.
Artificers.
Labourers.

The ladies, except those of Archbishops, bishops, and judges, take place according to the quality of their husbands, and unmarried ladies take place according to that of their fathers.

HERB, in Botany, is that part of the plant which rises from the root, and is terminated by the fructification. It comprehends the trunk and stem; the leaves; the fulcra, or supports; and the buds, or, as they are sometimes denominated, the winter quarters of the future vegetable.

HERBACEOUS PLANTS, in Botany, are those which have succulent stems that die down to the ground every year.

HERCULES, CERBERUS, and the *Apple Branch.* This constellation serves to perpetuate the memory of Hercules, the Theban, son of Amphitryon and Alcmene, famous in ancient times by his wisdom, his heroic labours, and his extraordinary strength. Hevelius placed Cerberus, or the Serpent with three heads, by the side of Hercules. If Cerberus be considered allegorically as the symbol of the earth, or more properly of all-devouring time, his three mouths will represent the present, past, and future. The victory which Hercules obtained over this monster is thought to denote the conquest this hero acquired over his passions. Dr. Bryant derives this name from *Kir Abor*, "the place of light," and the temple of the sun was called Tor-Caph-El, which was changed to τρικηφαλος, and hence Cerberus (originally the name of a place) was supposed to have three heads.

Boundaries and Contents.—On the N. by Draco, E. by Lyra S. by Serpentarius, and W. by Serpens and Corona Borealis. There are 113 stars in this constellation, of which seven are of the 3d magnitude, seventeen of the 4th, &c. *Ras Algothi*, of the 3d magnitude, is situated in the forehead, over the right eye. Ras Algothi, the principal star in this constellation, having 256° 36′ 32″ right-ascension, and 14° 36′ 17″ of N. dec., appears on the N. E. by E ¾ E. point of the horizon, and rises and culminates, at London, as in the following Table: Merid. Alt. 53° 5′ 17″ N.

MONTH.	RISES.	CULM.	MONTH.	RISES.	CULM.
	ho mi.	ho. mi.		ho. mi.	ho. mi.
Jan.	3 0 M.	10 20 M.	July	3 14 A.	10 28 A.
Feb.	12 50 M.	8 0 M.	Aug.	1 6 A.	8 30 A.
Mar.	11 2 A.	6 10 M.	Sept.	11 0 M.	6 30 A.
April	9 5 A.	4 15 M.	Oct.	9 10 M.	4 40 A.
May	7 15 A.	2 30 M.	Nov.	7 15 M.	2 45 A.
June	5 15 A.	12 30 A.	Dec.	5 10 M.	12 37 A.

HEREDITAMENTS, such things immoveable, whether corporeal or incorporeal, as a man may leave to his heirs, by way of inheritance; or which, not being otherwise devised, naturally descend. Corporeal hereditaments consist wholly of substantial and permanent objects, all of which may be comprehended under the general denomination of land only; incorporeal hereditaments are not the objects of sensation, are creatures of the mind, and exist only in contemplation. They are principally of ten sorts, *viz.* advowsons, tithes, commons, ways offices, dignities, franchises, presents, and rents.

HERMAPHRODITE, a term formerly applied exclusively to signify a human creature possessed of both sexes. The term is now applied to other animals, and to plants. It is now well known there is no such thing as an hermaphrodite in the human species. In most species of animals, the production of hermaphrodites appears to be the effect of chance, but in the black cattle it seems to be an established principle of their propagation. It is a well known fact, and, as far as has yet been discovered, appears to be universal, that when a cow brings forth two calves, one of them a bull, and the other a cow to appearance, the cow is unfit for propagation, but the bull-calf becomes a very proper bull. They are known not to breed; they do not shew the least inclination for the bull, nor does the bull ever take the least notice of them. Among the country people in England, this kind of calf is called a free-martin; and this singularity is just as well known among the farmers as either cow or bull. When they are preserved, it is for the purpose of an ox, or spayed heifer, *viz.* to yoke with the oxen, or fatten for the table. They are much larger than either the bull or the cow, and the horns grow longer and bigger, being very similar to those of an ox. The bellow of a free-martin is also similar to that of the ox, and the meat is similar to that of the ox or spayed heifer, *viz.* much finer in the fibre than either the bull or cow, and they are more susceptible of growing fat with good food.

Among the reptile tribe, indeed, such as worms, snails, leeches, &c. hermaphrodites are frequent. In the memoirs of the French Academy, we have an account of this very extraordinary kind of hermaphrodites, which not only have both sexes, but do the office of both at the same time. Such are earth-worms, round-tailed worms found in the intestines of men and horses, land-snails, and those of fresh waters, and all the sorts of leeches. And as all these are reptiles, and without bones, it is inferred, that all other insects which have two characters, are also hermaphrodites. The method of coupling practised in this class of hermaphrodites may be illustrated in the instance of earth-worms. These little creatures creep, two by two, out of holes proper to receive them, where they dispose their bodies in such a manner, as that the head of the one is turned to the tail of the other. Being thus stretched lengthwise, a little conical button, or papilla, is thrust forth by each, and received into an aperture of the other; these animals being male in one part of the body, and female in another.

Among the insects of the soft or boneless kind, there are great numbers indeed which are so far from being hermaphrodites, that they are of no sex at all. Of this kind are all the caterpillars, maggots, and worms, produced of the eggs of flies of all kinds. But the reason of this is plain; these are not animals in a perfect state, but disguises under which animals lurk. They have no business with the propagating of their species, but are to be transformed into animals of another kind, by the putting off their several coverings; and then only they are in their perfect state, and therefore, then only shew the differences of sex, which are always in the distinct animals, each being only male or female. These copulate, and their eggs produce those creatures which shew no sex till they arrive at that perfect state again.—*Watkin's Cyclopædia.*

HERMAPHRODITE *Flowers*, in Botany, are so called on account of their containing both the antheræ and stigma, the supposed organs of generation, within the same calyx and petals. Of this kind are the flowers of all the classes in Linnæus's method, except the classes monœcia and diœcia.

HERMETICAL PHILOSOPHY, is that which professes to explain all the phenomena of nature, from the three chemical principles of salt, sulphur, and mercury.

HERMETICAL *Sealing*, is used to denote a peculiar manner of stopping or closing glass vessels for chemical and other operations, so that not the rarest medium can either escape or enter. This is usually done by heating the neck of the vessel in the flame of a lamp with a blow-pipe, till it be ready to melt, and then with a pair of hot pincers twisting it close together.

HERSCHEL, the name frequently given to the new planet discovered by Dr. Herschel; it is otherwise called the Georgian, or Georgium Sidus, but now more commonly Uranus. Sir William Herschel, a very celebrated astronomer, who was originally a musician in a marching regiment, but by his genius and industry, raised himself to the honour of knighthood, and a name that will live whilst astronomical science shall be cultivated. This great observer and ingenious optician lived to a good old age, many years of which he passed at Slough, in the neighbourhood of Windsor, where the principal part of his observations on the heavens were made.

HESSE, WILLIAM, PRINCE OF, one of the greatest promoters and encouragers of the sciences in the sixteenth century. He erected an observatory at Cassel, and furnished it with excellent instruments for the purpose of observing the celestial motions; having called to his assistance Christopher Rothmann and Juste Byrgs: these observations were published by Wellebrord Snell at Leyden, in 1618, and are of a very curious nature; they are also mentioned by Tycho Brahe, in the second volume of his "Progymnasmata." This prince died in 1597.

HETEROGENEOUS, literally imports something of a different kind, in opposition to *homogeneous.*

HETEROGENEOUS *Bodies*, are bodies of unequal density and composition.

HETEROGENEOUS *Light*, that which consists of rays of different degrees of refrangibility.

HETEROGENEOUS *Numbers*, consisting of integers and fractions.

HETEROGENEOUS *Quantities*, are those which admit of no comparison as to greater or less. Thus, a surface and a solid are heterogeneous quantities, because we can in no way make comparison between them, or say that a surface, however large, is greater than a solid, however small. In this respect it has been said, that momentum and pressure are heterogeneous quantities.

HETEROGENEOUS *Surds*, are such as have different radical signs, as $\sqrt[2]{ax}$, $\sqrt{bb}$, $\sqrt[3]{9}$ $\sqrt[3]{18}$, &c. *See* SURD.

HETEROSCII, in Geography, are such inhabitants of the earth as have their shadows at noon projected always the same way with regard to themselves, or always contrary ways with respect to each other. Thus, all the inhabitants without the torrid zone are heteroscii, with regard to themselves, since any one such inhabitant has his shadow at noon always the same way; *viz.* always north of him in north latitude, and always south of him in south latitude.

HEXACHORD, in ancient Music, a concord called by the moderns a Sixth.

HEXAEDRON, or HEXAHEDRON, one of the five regular or platonic bodies, so called from its having six faces. The square of the side or edge of a hexahedron, is one-third of the square of the diameter of the circumscribing sphere: and hence the diameter of a sphere is to the side of its inscribed hexahedron, as $\sqrt{3}$ to 1.

HEXAGON, in Fortification, a place defended by six bastions.

HEXAMETER, in ancient Poetry, a kind of verse consisting of six feet; the first four of which may be indifferently either spondees or dactyls; the fifth is generally a dactyl, and the sixth always a spondee. Such is the following verse of Horace:

1 2 3 4 5 6
Aūt prō|dēssĕ vŏ|lūnt, āūt|dēlec|tārĕ pŏ|ētāē.

Sometimes, indeed, a spondee constitutes the fifth foot; whence such hexameter verses are called spondaic; as in this of Virgil:—

1 2 3 4 5 6
Cārā Dĕ|ūm sŏbŏ|lēs mā|gnūm Jŏvĭs| īncrē|mēntūm

Epic poems, as the Iliad, Æneid, &c. consist wholly of hexameter verses; whereas elegies and epistles consist usually of hexameter and pentameter verses alternately.

HIATUS, properly signifies an opening, chasm, or gap; but it is particularly applied to those verses, where one word ends with a vowel, and the following word begins with one, and thereby occasion the mouth to be more opened, and the sound to be very harsh. The term *Hiatus* is also used in speaking of manuscripts, to denote their defects, or the parts that have been lost or effaced.

HIDES, the skins of beasts; but is particularly applied to those of large cattle, as bullocks, cows, buffaloes, horses, &c. Raw or green hide, is that which has not undergone any preparation. There are also hides dried in the hair. Salted hide, is a green hide seasoned with sea salt and alum or saltpetre, to prevent its corruption. *See* CURRYING and TANNING.

HIDE *of Land*, was such a quantity of land as might be ploughed with one plough within the compass of a year.

HIERARCHY, the subordination of the clergy, ecclesiastical polity, or the constitution of the Christian church considered as a society.

HIEROGLYPHICS, in antiquity, mystical characters or symbols, in use among the Egyptians, and that as well in their writings as inscriptions; being the figures of various animals, the parts of human bodies, and mechanical instruments. The meaning of a few of these hieroglyphics has been preserved. They represented the Supreme Deity by a serpent, with the head of a hawk. The hawk itself was the hieroglyphic of Osiris; the river-horse, of Typhon; the dog, of Mercury; the cat, of the Moon or Diana; the beetle, of a courageous warrior. To decipher the more ancient hieroglyphics has hitherto baffled the ingenuity of the learned, but by a comparison of inscriptions which have been written in Greek, the hieroglyphic characters used for letters in writing proper names have been fully ascertained; and hence many inscriptions which were not accompanied by a corresponding Greek inscription, have been deciphered. In every other respect, the subject is in as much obscurity as ever.

HIGH WATER, that state of the tides when they have flowed to the greatest height, in which state they remain nearly stationary for about 15 or 20 minutes, when the water begins again to ebb. The time of high water is always nearly the same in the same place at the full of the moon, and at all other times the time of high water depends upon the age of the moon. The rule for finding which, the age of the moon being given, is as follows, *viz.* Add ⅘ of the days of the moon's age, as so many hours, to the time of high water at the full of the moon, and the sum is the time of high water, answering to that day *nearly*. The time of high water at London, on the day of the full moon, is three o'clock in the afternoon.

HIGHWAY, a public passage for the king's people, whence it is called the king's highway. There are three kinds of ways, a footway, a pack and prime way, which is both a horse and foot way, and a cart way, which contains the other two. A river, common to all men, may also be called the king's highway; and nuisances in any such ways are punishable by indictment. If passengers have used, time out of mind, where the roads are bad, to go by outlets on the land adjoining to an highway in an open field, such outlets are parcels of the highway; and therefore, if they are sown with corn, and the track is found and can be trodden, the king's subjects may go upon the corn. *See* ROAD.

Repairing Highways.—By the common law, the general charge of repairing all highways lies on the occupiers of the lands in the parish wherein they are. But it is said that the tenants of the lands adjoining are bound to scour their ditches.

Particular persons may be burdened with the general charge of repairing an highway, in two cases; in respect of an enclosure, or by prescription; but the parish cannot take advantage of this on the general issue, but must plead it specially. At common law, it is said, that all the county ought to make good the reparations of an highway, where no particular persons are bound to do it. By the ancient common law, villages are to repair their highways, and may be punished for their decay; and if any do injury to, or straighten the highway, he is punishable in the King's Bench, or before the justices of peace in the court-leet, &c. Destroying any public turnpike-gate, or the rails or fences thereto belonging, subjects the offender to hard labour, or transportation for seven years.

Every justice of the peace, by the statute, upon his own view, on on oath made to him by the surveyor, may make presentments of roads being out of repair; and thereupon, like process shall be issued as upon indictment.

HIN, a Hebrew measure of capacity for things liquid, containing the sixth part of an epha, or one gallon two pints, English measure.

HIND, a female stag in the third year of its age. *See* CERVUS.

HINGES, the joints on which gates, doors, lids, folds of tables, &c. hang and turn in opening, shutting, and folding.

HIP ROOF, among carpenters, called also *Italian Roof*, is a roof which has neither gable-head, shread-head, nor jerkenhead, (by which is meant such heads as are both gable and hip at the same end;) for it is a gable or upright, as high as the collar beam, and then there are two short hips, which shut up with their tops to the tops of a pair of rafters, which country carpenters call singlars. A hip-roof has rafters as long, and with the angle of the foot, &c. at the ends of buildings, as it has at the sides; and the feet of the rafters, at the end of such buildings as have hip-roofs, stand on the same plane, *viz.* parallel with the horizon, and at the same height from the foundation, with rafters on the sides of the roof.

HIPPOCRATES, of Chios, a celebrated mathematician of antiquity, who flourished about 450 years before Christ, and to whom we are indebted for the curious property of the lunes, which bear his name, and which were the first curvilinear spaces whose quadrature was precisely determined. *See* LUNES.

Hippocrates was originally a merchant, and is represented as having been a man of extreme simplicity, and very negligent of his own affairs, whereby he was nearly ruined. This circumstance brought him to Athens to arrange his concerns, and here it seems that, by chance, he first acquired some knowledge of geometry, which he afterwards prosecuted with the greatest success, and taught it in the school of Pythagoras, from which, however, it is said he was afterwards expunged for having received money for his instruction.

HIPPOPOTAMUS, in Natural History, a genus of mammalia, of the order belluæ. This animal is supposed to be the behemoth described in the book of Job. When full-grown, they are from 11 to 12 feet in length. Mr. Bruce reports, that they are occasionally found even of the length of twenty feet. Their form is awkward: the head astonishingly large, and the body extremely fat and round; the legs are very short and thick, and the teeth of vast strength and size. The whole animal is covered with short hair; its skin is so tough, as in some parts to resist a bullet; and its colour, when dry, is an obscure brown. It inhabits the warmer latitudes, and is to be found chiefly in the interior of Africa, in the largest rivers, in which it ranges at the bottom, sometimes reaching the surface for the purpose of respiration. By night it quits the water to feed, and devours a vast quantity of grass, and the tender branches of trees. Its disposition has nothing in it sanguinary or ferocious; it never attacks other animals. It frequently commits great depredations on the plantations of corn or sugar which are within the reach of its nocturnal progresses, and by destroying with its vast teeth the roots of trees. Its motion on land is inelegant and slow; yet if surprised and pursued, it runs with great speed till it reaches the water, into which it instantly plunges; and though it is able to swim with great rapidity, its progress in the water is at the bottom by walking. If wounded in the water, it sometimes is highly infuriated, and has been known to attack the boats or canoes, which it supposed to contain its enemy, and overturn them by its vast strength, or sink them by making a large hole in them with its teeth. It produces but one at a birth, generally in the little rushy isles of the rivers which it frequents, and in these islets it generally sleeps. When taken young, it is capable of being tamed. These animals are sometimes seen in considerable numbers, ranging for several miles beyond the banks of their rivers. They are valued by the natives of Africa for food, and the fat which it supplies is supposed to be equal to that of the hog. The feet are highly gelatinous, and regarded as a particular delicacy. With their skins the warriors of Africa are furnished with shields and bucklers. Their tusks are whiter than those of the elephant, and retaining their original clearness and beauty, are preferred by dentists for artificial teeth to every other substance.

HIRE, PHILIP DE LA, an eminent French mathematician and astronomer, was born at Paris in 1640. De la Hire was employed with Picard in making the necessary observations for constructing a new and accurate map of France, a task which he executed with the greatest ability, at the same time making other observations on the height of mountains, the variation of the magnetic needle, &c.

HIRUDO, the *Leech*, a genus of the vermes intestina class and order. The body moves either forward or backward. There are seventeen species, principally distinguished by their colour. The most remarkable is the medicinal leech, which grows to the length of two or three inches. The body is of a blackish brown colour, marked on the back with six yellow spots, and edged with a yellow line on each side; but both the spots and the lines grow faint, and almost disappear at some seasons. The head is smaller than the tail, which fixes itself very firmly to any thing the creature pleases. It is viviparous, and produces but one young at a time, which is in the month of July. It is an inhabitant of clear running waters, and is well known for its use in bleeding. The mouth of the leech is armed with a sharp instrument, that makes three wounds at once, and may be compared to the body of the pump, and the tongue or fleshy nipple to the sucker; by the working of this piece of mechanism the blood is made to rise up to the conduit which conveys it to the animal's stomach, which is a membranaceous skin, divided into twenty-four cells. The blood which is sucked out is there preserved for several months, almost without coagulating, and proves a store of provision to the animal. It is used in medicine, being applied to the skin in order to draw off blood. With this view they are employed to phlebotomize young children. If the leech does not fasten, a drop of sugared milk is put on the spot it is wished to fix on, or a little blood is drawn by means of a slight puncture, after which it immediately settles. The leech, when fixed, should be watched, lest it should find its way into the anus when used for the hemorrhoids, or penetrate into the œsophagus, if employed to draw the gums. In such a case, the best and quickest remedy is to swallow some salt; which is the method practised to make it loose its hold when it sucks longer than it was intended.

H. sanguisuga, horse leech: is clongated, olive-brown, with on ochre-yellow marginal band; found in stagnant waters, ditches, and ponds; from four to six inches long: body above dull olive black, with an ochre margin on each side; beneath paler, with sometimes a few black spots: tail thicker than the head. This species sucks blood with great avidity, and in large quantities.

HIRUNDO, the *Swallow*, in Natural History, a genus of birds of the order passeres. These live almost perpetually in the air, and perform in it every act of their nature. They subsist upon the insects with which that element abounds, and which they catch on the wing with admirable dexterity; and for this purpose they are furnished with a most extraordinary power of distending their jaws. The service they perform to man by their incessant assiduity in this work of destruction is not lightly to be appreciated, and those who observe the crowded population of the atmosphere through the beams of a summer evening, will easily be led to believe that, but for the interception of incalculable myriads of insects by these birds, the annoyance of man by these minute animals would be highly distressing, and perhaps almost intolerable. Various opinions have been formed of the state in which they exist during the time of their disappearance: some imagining them to lie torpid in the banks of rivers, or in decayed trees, or in ruined edifices or vaults: and others, that they retire for the winter from the air to the water, lying in immense clusters, like swarms of bees at the bottoms of rivers. Particular facts are on record, by respectable testimony, in favour of both these hypotheses. It is also attested, on similar authority, that migrations of these birds actually take place, and that they quit this country towards winter, for one where they may enjoy a milder climate, and more plentiful food. They are to be met with in every country of the world, and in all, or nearly so, are found to be migratory. There are thirty-seven species.

The house swallow, appears in March in this country, and leaves it in September. It generally builds in chimneys, or under the eaves of houses, and will return, unless interrupted, to its original haunt for a number of years. These birds breed twice a year. They are easily rendered familiar; and it has been calculated that a single swallow will devour from seven hundred to a thousand flies in one day.

The martin arrives in this country rather later than the swallow, and remains longer. It builds often in the crags of rocks near the sea; often under the eaves and cornices of houses. As soon as the young are able to fly, they are fed by the old birds upon the wing, by a process so rapid and instantaneous, as almost to be deemed incredible by those who have not actually witnessed it. Before their departure, they collect in immense flocks in the small islands of the Thames, where they roost, and in their flights about which they almost obscure by their numbers the face of the sky.

The swift arrives later and quits sooner than any other species, and is also larger and stronger. It builds in elevated situations, particularly about churches and steeples. As these birds catch at almost every thing in the air, they are taken sometimes by a cock-chaffer or other insects tied to a thread. They retire during the heat of the day, but in the morning and evening are incessantly on the wing, taking higher and bolder flights than the swallows, and always keeping separate from them. They leave this island in August.

The Chinese swallow, is said to be less than the wren by some authors, while others attribute to it the size of the martin. This bird is principally remarked for its nest, which is regarded as one of the greatest luxuries on which the epicure can banquet.

HISTORY, is a connected recital of past or present events. It is the office of the historian to trace the progress of man from the savage state and through the intermediate degrees of civilization, to the nearest approach to perfection of which social institutions are capable. It falls within his province to note the effects of laws and political regulations, and to record the revolutions which have been produced in states by external violence, or the gradual corruption of ancient systems of government. The record of past transactions, when diligently and minutely examined, will present to the politician matter of warning and of instruction, and, in a moral point of view, history is extremely useful, as it points out the issues of things, and exhibits, as its general result, the reprobation consequent upon vice, and the glory which awaits virtue.

The student of history must make himself master of the details of geography, the principles of statistical calculations, and the minutiæ of chonological researches. He ought likewise to be animated by a spirit of philosophical inquiry, that he may distinguish truth from falsehood, and be able to deduce useful consequences from the facts passing in review before him, in the obscure records of former times, or amidst the misrepresentations of factious malignity. He must have a minute knowledge of the human heart, and give due weight to circumstances and situations. Let him not direct his chief attention to the frivolous anecdotes of a court, but to the circumstances which stamp the character and decide the destiny of a nation.

HIVE. *See* Bee.

HOD, an instrument used to carry bricks and mortar in up ladders.

HOE, in country affairs, a tool made like a cooper's adze, to cut upwards, in gardens, fields, &c.

HOKE Day, the Tuesday after Easter week, which was the day on which the English conquered and expelled the Danes; this was therefore kept as a day of rejoicing, and a duty, called Hoke Tuesday money, was paid to the landlord, for giving his tenants and bondmen leave to celebrate it.

HOLCUS, *Indian Millet*, or *Corn*, a genus of the polygamia monœcia class and order of plants. Natural order of grasses. Essential character: hermaphrodite, calyx glume, one or two flowered; corolla glume, awned; stamina three; styles two; seed one; male, calyx glume, two-valved; corolla none; stamina three. There are 15 species.

HOLD, the whole interior cavity or belly of a ship, or all that part of her inside which is comprehended between the floor and the lower deck, throughout her length. This capacious apartment usually contains the ballast, provisions, and stores of a ship of war, and the principal part of the cargo in a merchantman; in the former it is divided into several apartments (by bulk-heads) which are denominated according to the articles which they contain, as, the fish-room, the spirit-room, the magazine, the bread room, &c. *See* the article Stowage.

The after Hold, is that which lies abaft the main mast, and is usually set apart for the stowage of the provisions in ships of war.

The fore Hold, denotes that part of the hold which is situated in the fore part of the ship, or about the fore hatchway. It is usually in continuation with the main-hold, and serves the same purposes.

*The main-*Hold, that part which is just before the main-mast, and which generally contains the fresh water and beer for the use of the ship's company.

Hold *Fast*, a large piece of iron, in the shape of the letter S, fixed into the wall to strengthen it. Also a tool used by joiners, carvers, &c. which goes through their benches to hold fast work that cannot be finished in the hand.

HOLLAND, a fine and close kind of linen, so called from its being first manufactured in Holland.

HOLLOW Square, in the Military art, a body of foot soldiers drawn up, with an empty space in the middle for colours, baggage, &c.

HOLOCENTRUS, a genus of the order of the thoracici, of which there are 35 species.

HOLOMETER, a mathematical instrument that serves universally for taking all measures, both on the earth and in the heavens.

HOME, in a Naval sense, signifies the situation of some object where it retains its full force of action, or where it is properly lodged for convenience or security. In the former sense, it is applied to the sails, and in the latter it usually refers to the stowage of the hold, or the anchors.

To haul Home *the Topsail-sheets*, is to extend the bottom of the top-sail to the lower yard-arms by means of the sheets.

Sheet Home *the Top-gallant-sails*, the order to extend the clues of those sails to the top-sail yard-arms.

In the stowage of the hold, a cask is said to be home when it bears against or lies close to some other object, and indeed the security or firmness of the stowage greatly depends on this circumstance.

The Cartridge is Home, *i. e.* is rammed close down, so as that the priming-wire may pierce it through the touch-hole.

HOMER, Omer, *Corus*, or *Chomer*, in Jewish antiquities, a measure containing ten baths, or seventy-five gallons and five pints, as a measure for things liquid; and thirty-two pecks and one pint, as a measure for things dry.

HOMICIDE, in Law, the killing of a man by man. Of this there are several species, as homicide by self-defence, homicide by misadventure, justifiable homicide, manslaughter, chance medley, and murder. Homicide by self-defence, or *se defendendo*, is where one has no other possible means of preserving his life from one who combats with him on a sudden quarrel, and kills the person by whom he is reduced to such inevitable necessity.

Homicide, by misadventure, is where a man in doing a lawful act, without any intent to hurt, unfortunately chances to kill another. Neither homicide by misadventure, nor homicide *se defendendo*, are felonious, because not accompanied with a felonious intent.

Homicide, *Justifiable*. To make homicide justifiable, it must be owing to some unavoidable necessity, to which a person who kills another must be reduced, without any manner of fault in himself. Justifiable homicide of a public nature is such as is occasioned by the due execution or advancement of public justice.

Homicide, *Manslaughter*, is either with or without malice; that which is without malice is called manslaughter, or sometimes chance medley, or chaud medley; by which is understood such killing as happens either on a sudden quarrel, or in the commission of an unlawful act, without any deliberate intention of doing any mischief at all. The only difference between murder and manslaughter is, that murder is upon malice aforethought, and manslaughter upon a sudden occasion.

Chance, or *Chaud Medley*. Authors of the first authority disagree about the application of this word. By some it is applied to homicide by misadventure, by others to manslaughter.

Murder is the highest crime against the law of nature that a man is capable of committing. It is, when a man of sound memory, and at the age of discretion, unlawfully kills another person under the king's peace with malice aforethought, either expressed by the party, or implied by the law, so as the party wounded or hurt die of the wound or hurt within a year and a day, the whole day on which the hurt was done, being reckoned the first.—The law so far abhors all duelling in cold blood, that not only the principal who actually kills the other, but also his seconds and those of the persons killed are accounted guilty of murder.

HOMINE Replegiando, a writ to bail a man out of prison.

HOMO, *Man*, in Natural History, is ranked by Linnæus under the order primates, which is characterized by having four cutting teeth in the upper and lower jaw, and two mammæ in the breast.

HOMOGENEAL, or Homogeneous, is a term applied to various subjects to denote that they consist of similar parts, or of parts of the same nature and kind; in contradistinction to heterogeneous, where the parts are of different natures, &c

Natural bodies are generally composed of homogeneous parts, as a diamond, a metal, &c. Artificial bodies, on the contrary, are assemblages of heterogeneous parts, or parts of different qualities, as a building of stone, wood, &c.

Homogeneal *Light*, is that whose rays are all of one and the same colour, degree of refrangibility, and reflexibility.

Thus if the ratio of A to B be the same as that of C to D A is homologous to C as B to D; because of the similitude between the antecedents and consequents. The two antecedents and the two consequents, then, in any continued geometrical proportion, are homologous terms

Thus, the base of one triangle is homologous to the base of another similar triangle; so in similar triangles, the sides opposite to equal angles are said to be homologous.

Equiangular, or similar triangles, have their homologous sides proportional.

All similar triangles, rectangles, and polygons, are to each other as the squares of their homologous sides.

HOMOGENEOUS Surds, those which have the same radical character or signs, as $\sqrt[2]{a}$, and $\sqrt[2]{b}$.

HOMOLOGOUS, in Geometry, an appellation given to the corresponding sides and angles of similar figures, as being proportional to each other.

HONE, a fine kind of whetstone, used for setting razors, &c.

HONEY, is a sweet and fluid substance, which is collected from flowers, and deposited in the cells of the combs for support of the bees and their offspring. The honey made by young bees is purer than any other, and is thence called *virgin honey*. Before the discovery of sugar, honey was of much greater importance than it is at present. Yet, both as a delicious article of food, and as the basis of a wholesome fermented liquor called *mead*, it is of no mean value even in this country; but in many parts of the continent, where sugar is much dearer than with us, few articles of rural economy, not of primary importance, would be dispensed with more reluctantly than honey. In the Ukraine, some of the peasants have each 400 or 500 bee-hives, and make more profit of their bees than of corn. And in Spain the number of hives is almost incredible; a single parish priest is stated to have possessed 5000.

HONEY-COMB, in Gunnery, is a flaw in the metal of a piece of ordnance, when it is ill cast and spongeous. See the article Gun.

HONOUR, in Law, is used especially for the more noble sort of seigniories on which other inferior lordships or manors depend, by performance of some customs or services to those who are lords of them. Before the statute 18 Edward I. the king's greater barons, who had a large extent of territory holden under the crown, frequently granted out smaller manors to inferior persons to be holden of themselves: which therefore now continue to be held under a superior lord, who is called in such cases the lord paramount over all these manors; and his seigniory is frequently termed an honour, not a manor, especially if it has belonged to an ancient feudal baron, or been at any time in the hands of the crown. When the king grants an honour with appurtenances, it is superior to a manor with appurtenances; for to an honour, by common intendment, appertain franchises, and by reason of those liberties and franchises, it is called an honour.

Honour, *Courts of*. Those which determine disputes concerning precedency and points of honour.

HONOURS, Military. All armies salute crowned heads in the most respectful manner, colours and standards dropping, and officers saluting. Different ranks of officers are saluted in a different mode.

Honours *of War*, are terms granted to a vanquished enemy, and by which he is permitted to march out of town, &c. with all the insignia of military etiquette.

HOOD, a sort of low wooden porch, resembling the companion, (which see) of the master's cabin, and is placed over the ladder which leads to the steerage in merchant ships. Its use is to prevent the rain from falling into the steerage, but at the same time to admit the air and light.

Hood, is also a name given to the upper part of a galley-chimney, which being in the shape of the letter L reversed, is trimmed or turned round according to the various directions of the wind, that the smoke may always fly to leeward.

Fore Hood, or *After Hood*, or *Whood*, or *Whooden Ends*, a name given to the ends of the planks which are let into the channels of the stem and stern-post.

Hood, *of a Pump*, a short semi-cylindrical frame of wood, serving to cover the upper wheel of a chain-pump.

Naval Hoods, or Whoods, large thick pieces of timber, which encircle the hawse-holes.

HOOK, a crooked piece of iron, of which there are several kinds, of different shapes and sizes, used at sea; as boat-hooks, breast-hooks, can-hooks, cat-hooks, fish-hooks, &c. which see. Foot-hooks are the same as Futtocks, which see.

Laying Hook, a winch for twisting a rope, used in rope-making.

Loof Hooks, a tackle with two hooks, one to hitch into a cringle of the main or fore-sail in the bolt-rope, at the leach of the sail by the clew, and the other is to hitch into a strap which is spliced to the chess-tree. Their use is to pull down the sail, and succour the tackle in a large sail or stiff gale, that all the stress may not bear upon the tack. It is also used when the tack is to be seized more secure, and to take off or put on a bonnet or drabler.

Hook *and Butt*, the scarfing or laying two ends of planks over each other.

Hook *Pins*, are bolts made with a shoulder at one end, and used by carpenters in framings.

HOOKE, Robert, a celebrated mathematician, was born in the Isle of Wight, in 1635, and very early gave proofs of a very superior genius: he was first an assistant to Dr. Wallis, and afterwards to Mr. Boyle, to whom he was very useful in the construction of his air-pump. He was a man of great mechanical genius, and the sciences are indebted to him for several valuable instruments and improvements. The following are the inventions and discoveries to which he laid claim:

The wheel barometer; a scapement for maintaining the vibration of the pendulum; the double-barrelled air-pump: the conical pendulum; an engine for cutting clock and watch wheels; a method of supplying air to a diving-bell; a reflecting quadrant; the marine barometer; the marine gage; a universal joint for mechanical purposes; besides a great variety of other mechanical contrivances, which our limits will not admit of detailing. His writings are both numerous and valuable; but all his discoveries and inventions are now the common property of science. Hooke was professor of mathematics in the Royal Society, and at Gresham College, London, where he died in 1702.

HOPPER, a kind of basket, wherein the seed-corn is carried at the time of sowing. It is also used for the wooden trough in a mill, into which the corn is put to be ground. *See* Mill.

HOPS, the dried flower-buds of a British climbing plant, which in some parts of England grows wild; but which generally are cultivated in plantations that require the growth of some years before they are in perfection. The plants begin to push up their young stems about the month of April. When these are three or four inches above the ground, poles about twenty feet high are driven in to support them in their growth. The season for picking hops usually commences about the middle of September. This work is performed by men, women, and children. Proper baskets, bins, or cribs, being in readiness, the plants are cut off close to the ground, and the poles drawn up. These are placed upon the bins, with the plants upon them, and three or more persons on each side pick off the hops. After this they are dried in a kiln, and when dry, are carried into, and kept for five or six days in an apartment called the stowage room, until they are in a state to be put into bags. This is done through a round hole, or trap, cut in the floor of the stowage-room, exactly equal to the dimensions of the mouth of the bag, and immediately under which to a frame of wood this mouth is fastened. In each of the lower corners of the bag a small handful of hops is tied; and a person called the packer places himself in it, and, by a heavy leaden weight, which he constantly moves round in the places where he is not treading, presses and forces the hops down, in a very close manner, into the bag, as fast as they are thrown to him by another labourer. The work thus proceeds till the bag is quite full, when each of the upper corners has a few hops tied in it, in the same manner.

HORARY, or Hour Circle of a Globe, is a small brazen circle, fixed upon the brazen meridian, divided into twenty-four hours, having an index moveable round the axis of the globe, which upon turning the globe fifteen degrees, will shew what places have the sun an hour before or after us.

Horary *Circles* or *Lines*, in Dialling, are the lines or circles which mark the hours on sun-dials. *See* Dialling.

Horary *Motion of the Earth*, the arch it describes in the space of an hour, which is nearly 15 degrees, though not accurately so, as the earth moves with different velocities, according to its greater or lesser distance from the sun.

HORDE, in Geography, is used for a company of wandering people, which have no settled habitation, but stroll about, dwelling in waggons or under tents, to be ready to shift as soon as the herbage, fruit, and the present produce, is eaten bare.

HORDEUM, in Botany, *Barley*, a genus of the triandria digynia class and order. Natural order of grasses. Essential character: calyx lateral, two-valved, one-flowered, by threes, at each toothlet of the rachis. There are nine species.

HORIZON, the line that seems to link the land or sea and sky; and it is either *rational* or *sensible*.

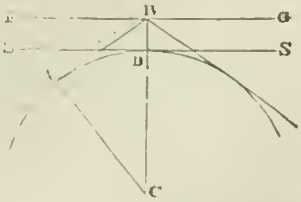
The *Rational*, *True*, or *Astronomical* Horizon, which is also called simply and absolutely the horizon, is a great circle, whose plane passes through the centre of the earth, and whose poles are the zenith and nadir. It divides the sphere into two equal parts or hemispheres.

The *Sensible*, *Visible*, or *Apparent* Horizon, is a lesser circle of the sphere, which divides the visible part of the sphere from the invisible. Its poles are likewise the zenith and nadir; and consequently the sensible horizon is parallel to the rational, and it is cut at right angles, and into two equal parts, by the vertical. These two horizons, though distant from each other by the semidiameter of the earth, will appear to coincide, when continued to the sphere of the fixed stars, because the earth compared with this sphere is but a point. The sensible horizon is divided into eastern and western.

The *Eastern* or *Ortive* Horizon, is that part of the horizon wherein the heavenly bodies rise.

The *Western* or *Occidual* Horizon, is that wherein the stars set.

By sensible horizon is also frequently meant a circle, which determines the segment of the surface of the earth, over which the eye can reach; called also the physical horizon. In this sense we say, a spacious horizon, a narrow scanty horizon.



It is manifest, from the annexed figure, that the higher the spectator is raised above the earth, the farther this visible horizon will extend, as the respective distances A D, B A, will be the greater. On account of the refraction of the atmosphere, distant objects on the horizon appear higher than they really are, or appear less depressed below the true horizon S S, and may be seen at a greater distance, especially on the sea. Legendre says, that, from several experiments, he is induced to allow for refraction a 14th part of the distance of the place observed, expressed in degrees and minutes of a great circle. Thus, if the distance be 14,000 toises, the refraction will be 1000 toises, equal to the 57th part of a degree, or 1′ 3″.

Horizon *of a Globe*, the broad wooden circular ring in which the globe is fixed. On this are several concentric circles, which contain the months and days of the year, the corresponding signs and degrees of the ecliptic, and the 32 points of the compass.

Artificial Horizon, is a contrivance intended to be employed in taking altitudes with Hadley's quadrants, of which there are several constructions.

HORIZONTAL, something relating to the horizon; or that is taken in, or on a level with the horizon.

Horizontal *Dial*, is one drawn on a plane parallel to the horizon, having its gnomon or style elevated according to the altitude of the pole of the place it is designed for.

Horizontal *Distance*, is that estimated in the direction of the horizon.

Horizontal *Line*, in Perspective, is a right line drawn through the principal point, parallel to the horizon; or it is the intersection of the horizontal and perspective planes.

Horizontal *Line*, or *Base of a Hill*, in Surveying, a line drawn on the horizontal plane of the hill, or that on which it stands.

Horizontal *Plane*, in Perspective, a plane parallel to the horizon, passing through the eye, and cutting the perspective plane at right angles.

Horizontal *Range*, of a piece of ordnance, is the distance at which a ball falls on or strikes a horizontal plane, whatever be the angle of elevation or direction of the piece. When the piece is pointed parallel to the horizon, the range is then called the point-blank, or point-blank range. The greatest horizontal range, in the parabolic theory, or in a vacuum, is that made with the piece elevated to 45 degrees, and is equal to double the height from which a body must freely fall, to acquire the velocity with which the shot is discharged. But in a resisting medium like the atmosphere, the elevation of the piece, to shoot farthest, is always below 45 degrees, and gradually the more below it as the velocity is greater; so that the greater velocities with which balls are discharged from cannon with gunpowder, require an elevation of the gun equal to but about 30 degrees, or even less. And the less the size of the balls is, too, the less must this angle of elevation be, to shoot the farthest with a given velocity. *See* Gunnery.

Horizontal *Speculum*, consists in a well polished metal speculum, about three or four inches in diameter, enclosed within a rim of brass; so fitted, that the centre of gravity of the whole shall fall near the point on which it turns.

HORN. The horns of oxen are used for many of the same purposes as bone. After having been softened by heat, they are capable of being moulded into almost any shape. They are sometimes stained in such a manner as to imitate tortoise shell, and are then used for the making of combs. By a peculiar process they are rendered semi-transparent, and when formed into thin plates, are employed instead of glass for lanterns. Horn was the first transparent matter that was ever used for lanterns and windows.

Horn, is also a musical instrument of the wind kind. The French horn is bent into a circle, and goes two or three times round, growing gradually bigger and wider towards the end, which in some horns is nine or ten inches over.

Horns *of Insects*, the slender oblong bodies projected from the heads of those animals, and otherwise called antennæ, or feelers. The horns of insects are extremely various; some being forked, others plumose or feathered, cylindrical, tapering, articulated, &c. Some have imagined they served to wipe and defend the eyes; others, that they served as feelers, lest the creature should run against any thing that might hurt it; and others think them the organs of smelling.

Horn *Ore*, in Mineralogy, is one of the species of silver ore; its most frequent colour is pearl-grey. It is found massive, disseminated in thick membranes, in roundish hollow balls; also crystallized. It occurs in veins, and is usually accompanied with brown iron ochre, and with silver glance.

HORNSTONE, or Hornsteen, in Mineralogy, a species of the flint genus, divided into three sub-species: the splintery, the conchoidal, and the woodstone. The most common colour of the splintery hornstone is gray; it is found in veins, in the shape of balls, in lime-stone. The best mill-stone, called French burr, is cellular splinter hornstone. Conchoidal hornstone occurs in beds with agate, and is distinguished from the splintery by the lightness of its colours and fracture. In the woodstone several colours occur together, and it commonly exhibits coloured delineations, arranging themselves in the direction of the original woody texture.

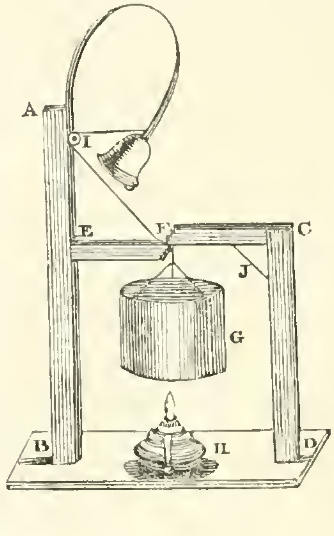
Horn *Work*, in Fortification, an outwork composed of two demi-bastions, joined by a curtain.

HORNBLENDE, in Mineralogy, a species of the clay genus, of which there are four sub-species; *viz.* the common, the Labrador, the basaltic, and the hornblende slate. The common hornblende is of a greenish black, or raven-black, which in some varieties approaches to a grayish and even velvet black. The common hornblende forms one of the essential ingredients of several mountain rocks. When pure, it is a capital flux for iron ores, to which purpose it is applied in Sweden. The Labrador hornblende, found in the island of St. Paul, on the coast of Labrador, is usually of a brownish black. The hornblende slate is of a colour intermediate between greenish and raven black: it is massive, and is generally mixed with mica and felspar. It occurs in beds of primitive rocks, particularly in clay slate; also in gneiss and mica slate, and is found principally in the northern parts of Europe. The basaltic hornblende is of a velvet black, occurs almost always in single imbedded crystals. The surface is smooth and shining, except where it happens to be covered by a thin ochery crust.

HOROLOGIUM, *the Clock*, in Astronomy, is a modern constellation, bounded on the N. and W. by Eridanus, S. by Hydrus, and E. by Reticulus Rhomboidalis, Dorado, and Equuleus Pictorius.

HOROLOGY, that branch of mechanical science which enables us to measure the portions of time. We judge of the lapse of time by the succession of sensible events; and the most convenient and accurate measures of its quantity are derived from motions, either uniform, or repeated at equal intervals. Of the former kind the rotation of the earth on its axis is the most exact, and the situation of its surface with regard to the fixed stars, or less simply with regard to the sun, constitutes the means for determining the parts of time as they follow each other. Of the latter kind, the rotation of machinery, consisting of wheel-work, moved by a weight or spring, and regulated by a pendulum or balance, affords instruments of which the utility is well known. But the term horology is at present more particularly confined to the principles upon which the art of making clocks and watches is established. *See* Clock, Dialling, Watch, &c. Under this article we may describe some Alarums.

Simple Alarum.—An alarum being a most useful piece of furniture, at one time or another, in every house, perhaps the sketch of one, both cheap and simple, as well as original, may not be unacceptable to our readers.



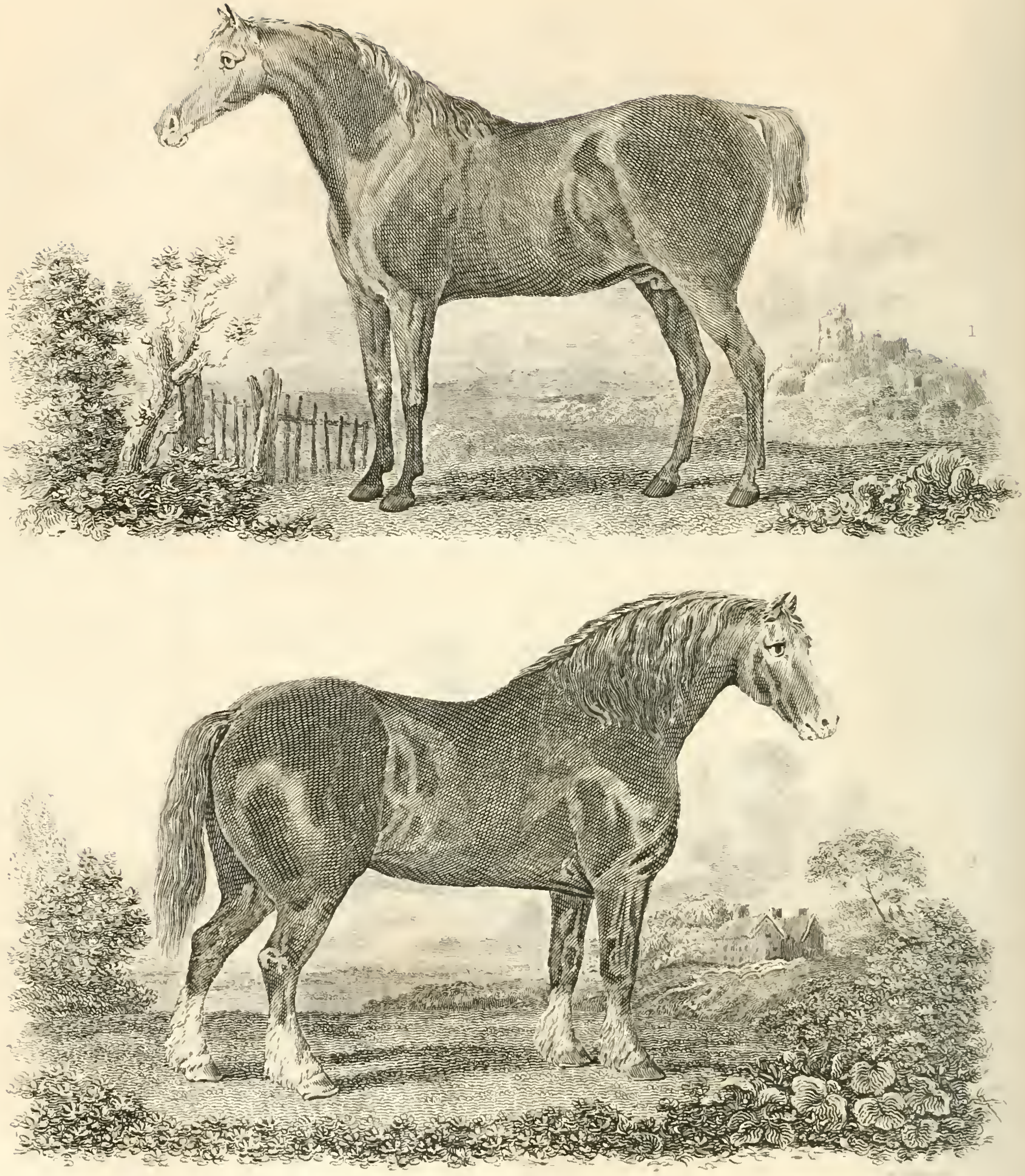
Description.—A B and C D are two uprights, of wood.

E F and F C are two small pieces of wood, with small hinges or pins, at E and C.

G is a vessel made of glass or tin, and suspended from F, to contain water, under which is placed the lamp, H.

By the heat of the lamp the water gradually evaporates or flies off in steam, which, lightening the vessel, G, allows the piece of wood, E F, moving on the hinge at E, to escape from under the point, F, of the piece of wood, F C, which flies up, from the strength of the

HORSES.



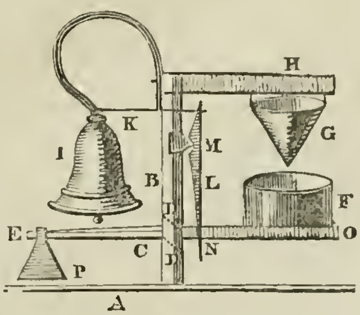
1. BLOOD HORSE. 2. CART HORSE.

spring of the bell, to the wheel or pulley, I, and thus sets the bell at liberty and causes it to ring.

J is a bracket or triangular piece of wood, to prevent the vessel, G, from falling on the lamp after the bar, EF, has escaped from under it.

The quantity of water for a certain number of hours, the size of the wick, &c. can be calculated, with ease, from a few hours' observation. A slit should be cut perpendicularly in the piece F C, so that the thread by which the vessel is suspended may be shifted nearer towards C, as occasion may require.

Cheap Alarum.—A is a board about a foot square, in the centre of which is inserted an upright piece B, through which a cross piece, C, passes, confined by a wire pin, but having the aperture through which it passes in the upright piece B, cut as described by the dotted lines at D D. To the end E is attached a weight, moveable backwards or forwards at pleasure. On the opposite end of the beam C, is fixed a tin vessel, F, which receives the sand as it runs out of the funnel G, which is fastened to a fixed beam, H. I is a common spring bell, also fixed to the top of the upright post, B. K is a wire, or piece of fine cord passing from the spring of the bell to the upper end of a small lever, L, which traverses on an axle, M, fixed to the side of the upright piece B, the other or lower end of the leaver L presses against a peg, N, projecting from the side of the cross beam C, which retains the lever L in the position represented in the figure, and confines the spring of the bell, till the weight of the sand run out of the funnel G into the vessel F more than counterbalances the weight at the end, E, when, of course, the end, O, of the cross beam will be depressed, which will suddenly release the lower end of the lever L from the peg N, and thus the spring of the bell will re-act with sufficient force to put the bell in motion. Any quantity of sand may be put into the funnel G: thus if 2 ounces should run one hour, 12 ounces will run six; therefore by having the weight P 12 ounces (after having balanced the cross beam C with the empty vessel F,) it is obvious that as the sand continues running, in a few minutes the vessel containing the sand must predominate and be depressed, which is all that is required, as shewn in the figure.



HOROSCOPE, in Astrology, is the degree of the ascendant, or the star that rises above the horizon, at a certain moment, which is observed in order to predict some future event. The same name is also given to a scheme or figure containing the twelve houses, in which are marked the situation of the heavens and stars, in order to form predictions.

Horoscope *Lunar*, the point from which the moon proceeds when the sun is in the ascending point of the east.

HORS de Combat, a term in use in the French army, to express the total loss to an army by a battle, including killed, wounded, prisoners and deserters.

Hors *de Son Fee*, an exception to avoid an action brought for rent issuing out of certain lands, by him that pretends to be the lord, or for some custom and services; for if the defendant can prove the land to be without the compass of his fee, the action fails.

HORSE, a rope reaching from the middle of a yard to its arms or extremities, and depending about two or three feet under the yard, for the sailors to tread on while they are loosing, reefing, or furling, the sail; rigging out the studding sail booms, &c. In order to keep the horse more parallel to the yard, it is usually attached thereto at proper distances, by certain ropes called stirrups, which hang to their lower ends, through which the horse passes.

Horse, signifies also a thick rope, fixed perpendicularly fore or aft a mast, for the purpose of hoisting some yard.

The Horse is distinguished from every other quadruped, by having his hoofs single, and his tail covered with long hair. The male has the name of *horse*, the female of *mare*, and the young one of *foal*. Wild horses are found in large herds in Siberia, and several other parts of Asia, as well as in some parts of Africa. Endowed with the most useful qualifications, the horse is an animal of the greatest importance to the inhabitants of all temperate climates. Though naturally spirited, active, and intrepid, he submits with patience to carry burdens, and to toil for days together along the roads and in agricultural labours; and, if treated with care and attention, he perseveringly adapts himself to our wants and conveniences. In some parts of Tartary, these animals have even been made objects of divine worship, originating no doubt in a principle of gratitude for the services they perform. By the Arabians, they are nearly as much attended to and beloved as human beings; living in the same tents with their owners, and participating in all the kindnesses which they bestow upon their own families. In Arabia, indeed, these animals may be deemed the chief support of the families who possess them; and (surrounded with foes) the very existence of the owner not unfrequently depends upon the powers of his horse.

In no country of Europe is so much attention paid to the breeding and training of horses as in England. The consequence has been, that the British horses are superior both in swiftness of foot, and in strength and perseverance in the course, to any others in this quarter of the world.

The fleetest of all the British horses is of course the *race-horse*; and, for short distances, none of the Arabians which have been tried in England have proved in any degree equal to him. The celebrated horse, called Childers, in the year 1721, ran four miles in six minutes and forty-eight seconds, carrying a weight of nine stone two pounds. Had the different racing meetings at Newmarket, York, and other places, no other view than to call together great concourses of people for amusement, their tendency would be injurious rather than beneficial to society; but when it is considered that such meeting are the cause of great emulation in the breeding of a race of animals so valuable as the horse, their utility will be sufficiently apparent.

The English *hunters* are allowed to be among the noblest, most elegant, and most useful animals that are known; and the value of our *hackneys* or road horses may be imagined, when it is stated that many of them are able to trot at the rate of more than fifteen miles per hour. In the year 1745 the postmaster of Stretton is stated to have ridden on different horses along the road to and from London, no fewer than 215 miles in eleven hours and a half, which is at the rate of above eighteen miles an hour.

So great is the strength of these animals, that instances have been mentioned of a single horse drawing, for a short space, the weight of three tons; and of others carrying a load which weighed more than 900 pounds. The immense *dray-horses* which are employed by the brewers, and are so frequently seen in the streets of London, though in some measure useful as being able better to sustain the shock of loading and unloading than slighter animals, are chiefly kept from a principle of ostentation. The British *draught-horses* are extremely valuable animals, but particularly a chesnut-coloured race called Suffolk horses.—See the *Plate.*

In Scotland there is a breed of small horses or ponies, which are known by the name of *galloways* The best of these seldom exceed the height of fourteen hands and a half,* and are extremely active, hardy, and spirited animals. The Shetland islands produce a race called *shelties*, which, though exceedingly diminutive in size, are in other respects highly excellent.

In Ireland, the cart-horses, though of sufficient size, are ill shaped and bad. The saddle-horses appear naturally as good as ours; but in general they are ill kept, worse groomed, and still worse shod.

There is a prevalent and erroneous notion, that the *flesh* of the horse is bitter and unpalatable. In several parts of Asia wild horses are killed almost exclusively for food; and the Calmuc Tartars, in particular, are so partial to this kind of flesh, that they seldom eat any other. Horses' flesh is constantly exposed for sale in the markets of Tonquin. A celebrated British writer (Dr. Anderson) has strongly recommended the fattening of horses as food in this country, and urges his recommendation by declaring that horse-flesh is superior in delicacy of flavour to beef!

---

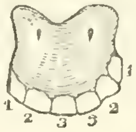
* Four inches make a hand. This is the usual mode of estimating the height of horses.

The Tartars drink the *milk* of the mare, and also convert it into butter and cheese. One of their most favourite kinds of beverage is called *koumiss*, which is a sort of wine made of fermented mares' milk; and is carried by them from place to place, in bags made of horses' hides. When in perfection, the taste of koumiss is said to be a pleasant mixture of sweet and sour; but it is necessary to agitate it before it is drank. This preparation is also considered of great utility in a medicinal view.

The *skin* of the horse, after it is tanned, is made into collars, traces, and other parts of harness; and under the name of *cordovan* is also used for shoes. The *hair* forms a considerable branch of trade. That of the tail is employed for weaving the covers or seats of chairs and sofas; for making sieves, fishing-lines, and the bows of musical instruments. The inferior hair of the tail and mane is employed for the stuffing of bolsters and mattresses. For this purpose it is baked, which renders it one of the most elastic substances for couches that are known. The short hair of the horse is used for stuffing saddles and horse-collars.

If horses be well treated and properly attended to, they will sometimes live to the age of fifty years; but during a great part of this time, they are generally so decrepit as to be unable to perform any services whatever for their owners. To ascertain the age of a horse, reference is generally had to the teeth. Every treatise on farriery has instructed us to know a horse's age by the mark in his mouth; but not one in five hundred (a dealer excepted) can retain it in his mind. We have endeavoured, therefore, to represent it by engravings.

Fig. 1.



Every horse has six teeth before in each jaw: till he is two years and a half old, they are all smooth and uniform in their upper surfaces, fig. 1. At two years and a half old he sheds the two middle teeth (by the young teeth's rising and forcing the old ones out, as at fig. 2,) which at three years old are replaced by two hollow ones, as at fig. 3. When he is about three years and a half old, he sheds two others, one on each side the two middle ones, fig. 4, which at four years old are replaced by two others, which are also hollow, as at fig. 5. The sharp single teeth in horses, (fig. 4,) begin to appear in the lower jaw when the horse is about three years and a half or four years old. when he is nearly six years old, they are full grown, pointed, and concave in the inside, as at fig. 5. When he is four years and a half old, he sheds the two corner teeth, fig. 6, which at five are replaced also with two hollow ones, grooved on the inside, as at fig. 7, which groove marks the age precisely. At six years of age this groove begins to fill up, and disappear, as at fig. 8, so do the hollows of the rest of the teeth, which continue till near seven and a half or eight years old, when all the teeth become uniformly full and smooth, as at fig. 9. Crafty jockeys will sometimes burn holes in the teeth, to make them appear young, which they call bishoping; but a discerning eye will soon discover the cheat.

Fig. 2.

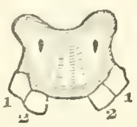


Fig. 3.

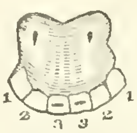


Fig. 4.

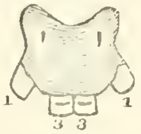


Fig. 5.

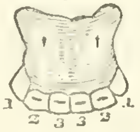


Fig. 6.

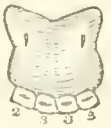


Fig. 7.

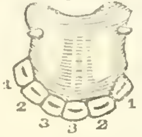


Fig. 8.

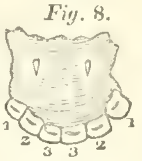
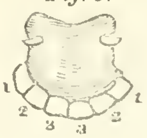


Fig. 9.



By inspecting the eyes also, we may know the condition of a horse, especially as to sight: thus, if a horse's eyes are lively and clear, and you can see to the bottom, and the image of your face be reflected from thence, and not from the surface of the eye, they are good; but if muddy, cloudy, or coal-black, they are bad.

With respect to his legs, you ought to observe whether his knees are broken, or stand bending and trembling forward; if so, the animal is unsound; if he steps short, and digs his toes in the ground, it is a sign he will knuckle. In short, if the hoof be pretty flat and not curled, you need not fear a founder.

As to his wind, if his flanks beat even and slow, his wind may be good, but if they heave double and irregular, or if (while he stands in the stable) he blows at the nostrils, as if he had just been galloping, they are signs of a broken wind. Deceitful dealers have a draught which they sometimes give, to make a horse breathe regularly in the stable; the surest way therefore to judge of his wind, is, to give him a good brushing gallop, and it is ten to one, if his wind be broken, or even touched, that he will cough and wheeze very much, and no medicine can prevent his doing so. In buying a horse, inquire whether he bites, kicks, stops, and starts; for a horse may be perfectly sound, and yet guilty of these four vices. And a good sound horse has neither splint, spavin, nor windgall, which are excrescences and swellings about the legs. But this is not a treatise on farriery.

Shoeing of Horses.—The shoes should be made three times as thick at the toe as at the heels, so that by this means the frog may come down to the ground. The nails are all placed forward, four on each side, but not approaching too near the heels. They should be counter-sunk in conical or wedge-shaped holes. For horses which go in shafts, or are used in hunting, it is usual to make shoes with only one heel, which should be outward. The horse's heel must be rather lowered on that side, and the inner heel of the shoe somewhat thickened, so as to balance and bear equally. The best breadth for the shoe of a medium-sized horse is said to be one inch at the toe, and three-quarters at the heel; the weight about eighteen or twenty ounces. In order to fit the shoe without causing the horse to stand too much on his heels, the under part of the crust, or wall of the hoof, is pared away to receive the excess of thickness in front; for the bottom of the shoe ought to be perfectly flat, without any stubs or calkings in front. Paring away the heels is a most destructive practise, except in case of absolute excrescence in those parts: nor should the bars, (or diagonal ridges) that extend from the heels to the frog, or central projection, ever be cut more than is absolutely proper for the purpose of keeping them in a clean and healthy state. A good open heel is the indication of a powerful foot; hence the sides of shoes ought not to be much contracted. When the heels are tender, what is called a bar-shoe ought to be applied. On the frog the horse chiefly depends for a spring, or resistance at the bottom of his foot. If this part does not touch the ground, the whole motion will be derived from the upper parts of the limb, and a very uneasy gait will inevitably follow. This points out the necessity for leaving it fully at liberty to come in contact with the ground.

HORSE *Dealers.* Every person exercising the trade or business of a horse-dealer, must take out a license from the Stamp-office. Horse-dealers carrying on business without a license, are liable to be assessed the duties on riding horses.

HORSES. It is lawful for any person to transport, by way of merchandise, horses into any parts beyond the seas in amity with his majesty, paying for each 5*s*. No person convicted of feloniously stealing a horse, shall have the privilege of clergy; accessaries before or after, are also deprived of the benefit of their clergy. If a horse be stolen out of the stable, or other curtilage of a dwelling-house, in the night time, it falls under the denomination of burglary; if in the day-time, it falls under the denomination of larceny from the house. Keepers of slaughter-houses for horses, are subject to regulations enacted by an act of 26 Geo. III. c. 74. If any person shall unlawfully and maliciously kill, maim, or wound any cattle, every person so offending, shall be adjudged guilty of felony. If a horse, or other goods, be delivered to an innkeeper, or his servants, he is bound to keep them safely, and restore them when his guest leaves the house. If a horse be delivered to an agisting farmer for the purpose of depasturing in his meadows, he is answerable for the loss of the horse, if it be occasioned by the ordinary neglect of himself or his servants. If a man ride to an inn where his horse has eat, the host may detain the horse till he be satisfied for the eating.

HORTUS SICCUS, or Dry Garden, is an appellation given to a collection of specimens of plants, carefully dried and preserved. Plants may be dried by pressing in a box of sand, or with a hot smoothing iron; and each of these methods has its advantages. If pressure be employed, a couple of boards, about 18 inches long, 12 broad, and 2 thick, with screws at each corner and nuts on them, something like a bookbinder's press, will do very well; or the plants may be put between the leaves of a blotting paper book made on purpose, and weights laid on the book till the plants are dried. Next, some quires of unsized blossom blotting paper must be provided. The specimens, when taken out of the tin box, must be carefully spread on a piece of pasteboard, covered with a single sheet of the blossom paper quite dry; then place three or four sheets of the same paper above the plant, to imbibe the moisture as it is pressed out; it is then to be put into the press. As many plants as the press will hold may be piled up in this manner. At first they ought to be pressed gently. After being pressed for twenty-four hours or so, the plants ought to be examined, that any leaves or petals which have been folded may be spread out, and dry sheets of paper laid over them. They may now be replaced in the press, and a greater degree of pressure applied. The press ought to stand near the fire, or in the sunshine. After remaining two days in this situation, they should be again examined, and dry sheets of paper be laid over them. The pressure then ought to be considerably increased. After remaining three days longer in the press, the plants may be taken out, and such as are sufficiently dry may be put in a dry sheet of writing-paper. Those plants which are succulent may require more pressure, and the blossom paper again renewed. Plants which dry very quick, ought to be pressed with considerable force when first put in the press; and, if delicate, the blossom paper should be changed every day. When the stem is woody, it may be thinned with a knife, and if the flower be thick or globular, as the thistle, one side may be cut away; as all that is necessary in a specimen, is to preserve the character of the class, order, genus, and species. Plants may be dried in a box of sand in a more expeditious manner; and this method preserves the colour of some plants better. The specimens, after being pressed for ten or twelve hours, must be laid within a sheet of blossom paper. The box must contain an inch deep of fine dry sand, on which the sheet is to be placed, and then covered with sand an inch thick: another sheet then may be deposited in the same manner, and so on, till the box be full. The box must be placed near a fire for two or three days. Then the sand must be carefully removed, and the plants examined. If not sufficiently dried, they may again be replaced in the same manner for a day or two. In drying plants with a hot smoothing iron, they must be placed within several sheets of blotting paper, and ironed till they become sufficiently dry. This method answers best for drying succulent and mucilaginous plants. When properly dried, the specimens should be placed in sheets of writing-paper, and may be slightly fastened by making the top and bottom of the stalk pass through a slip of paper, cut neatly for the purpose. Then the name of the genus and species should be written down, the place where it was found, nature of the soil, and season of the year. These specimens may be collected into genera, orders, and classes, and titled and preserved in a portfolio or cabinet.

HOSPITAL, William Francis Antony, Marquis de l', a celebrated French mathematician, was born of an ancient family in 1661. He was a geometrician almost from his infancy; for one day being at the Duke of Rohan's where some able mathematicians were speaking of a problem of Pascal's, which appeared to them extremely difficult, he ventured to say that he believed he could solve it; in a few days he sent them the solution. He entered early into the army, and was a captain of horse; but being extremely short-sighted, and exposed on that account to perpetual inconveniences and errors, he at length quitted the army, and applied himself entirely to his favourite amusement. He contracted a friendship with Malbranche, and took his opinion upon all occasions. In 1693, he was received an honorary member of the Academy of Sciences at Paris; and soon after published a work upon Sir Isaac Newton's Analysis.

Hospital, a place or building, erected, endowed, or supported, by charitable contributions, for the reception and relief of the aged, infirm, and helpless. The institution is very ancient, and the benefits resulting from it are incalculable. In London alone, and its suburbs, there are upwards of thirty hospitals; some bearing a name corresponding with the diseases for the cure of which they were established, and others taking their appellation from the place in which they stand, or the means by which they are supported. Many among them are amply endowed, but the rules and regulations by which they are governed, are too voluminous and diversified to be given in detail.

HOT-Beds, in Gardening, beds made with fresh horse-dung, or tanner's bark, and covered with glasses to defend them from cold winds. According to the quantity and quality of the materials put together for hot-beds, the heat will be porportioned as to strength and duration. The place where hot-beds are worked should be open to the full sun, and be screened from the north and north-east winds. Working of the dung is necessary previous to the making of a hot-bed, *i. e.* it should be thrown together on a heap, in a conical form; and when it has taken a thorough heat, it should be turned over, moving the outside in, or mixing the colder parts with the hot. When it has taken heat again for two or three days, give it a second turn as before, and having lain the same time, it will be in proper order for making a good lasting bed with a steady heat.

Hot-*House*, an erection warmed by means of flues, for the culture of tender exotics of tropical climates. The site of a hot-house is extremely important. A south-west aspect is to be preferred.

HOUNDS, in sea-faring language, are those parts of a mast-head which gradually project on the right and left side beyond the cylindrical or conical surface. These hounds support the frame of the top, together with the topmast and the rigging of the lower-mast.

HOUR, is the twenty-fourth part of a natural day. Different people reckon the hours in a different manner. Babylonish hours are those which are counted from sun-rising in a continued series of twenty-four. European hours are those counted from midnight, twelve from thence to noon, and from noon to midnight twelve more. Those which commence their order from noon are called *astronomical*, because used by astronomers. The Jews, Chaldeans, Arabs, and other eastern people, divide their hours into a *thousand* and *eighty* scruples, eighteen whereof are equal to our minute.

HOUSE, in Astrology, denotes the twelfth part of the heavens.

House, the common dwelling of man in civilized society. We shall, under this definition, consider the several parts of which a building for our accommodation is composed. The article will necessarily include all those particulars deserving of notice to the bricklayer, the mason, the carpenter, and proprietor or occupier of a house.

I. *Brickmaking, &c.*—The art of bricklaying or building with bricks is of great antiquity, and appears to be coeval with the earliest edifices on record. The making of bricks for building has been variously practised among different nations. The Babylonians often impressed or engraved inscriptions on their bricks in a character which has given rise to much discussion among the learned. The ancient Greeks chiefly used three kinds of bricks; bricks of two or three palms in length, those of four palms, and those of five palms. The Romans, from a comparative deficiency of marble, built more with bricks than the Greeks, and employed the arch, and the vault, to which this useful material so much contributed, more than their predecessors. Their bricks, according to the authority of Pliny, were about seventeen inches long, and eleven broad, and scarcely thicker than our paving bricks. Palladio, Sir Christopher Wren, and other eminent modern architects, have constructed beautiful and well-proportioned edifices in brick.

Bricks, as manufactured in England, are always burned or baked. Unburnt bricks, after the ancient mode, are still in use in Egypt, and many parts of the East. The modes of making bricks in Great Britain are various: those manufactured in the country differ from those made in the neighbourhood of the metropolis, and are distinguished by their colour; the former being a deep red, and the latter a yellow, stone colour, and gray. The country bricks, which are baked in a kiln, are made of a stronger earth, and have no internal firing; but the London method is beginning to be adopted near all large towns, both in England and in Ireland, where cinders and coal ashes can be procured, and by far the greatest quantity of bricks are now made in that manner.

On comparing the strength and durability of modern bricks with those of ancient times, it is evident that the former are in every respect inferior. The ancients selected the best sort of clay, and combined it with other ingredients well adapted to improve its properties. In the southern provinces of Russia, in the stupendous Tartary mountains, bricks which scarcely yield to the hammer, owe their excellence to the ancients burning them uniformly, after they had been thoroughly dried. No doubt can be entertained, that if modern brickmakers were to pay more attention to their art, by digging the clay at proper seasons, exposing it much longer to the air than is done at present, working it sufficiently, bestowing more care upon the burning of the bricks, and that the latter operation may be done uniformly, making them much thinner than is prescribed by the standard form, we should be provided with bricks equal in point of strength and durability to the best of former times. In a variety of instances, persons may have it in their power to obviate some of these causes of defect, and it is therefore proper to mention them; but the state of society is not favourable to any general change in the system which brickmakers pursue; the expedition with which a given number of bricks can be furnished, and the cheapness of the rate at which they can be manufactured, are to them the primary objects of consideration; and the speculative builder cares little about the real value and durability of his edifice, provided the difference between the cost and sale price is sufficiently ample to recompense him to his satisfaction.

It is an erroneous notion that bricks may be made of any earth that is not stony, or even of sea ooze; too much sand entering into their composition, renders them heavy and brittle, and too much fat argillaceous matter causes them to crack in drying: those only will burn red which contain iron particles. In England they are chiefly made of a motley, yellowish, or somewhat reddish fat clayey earth, commonly called *loam.* Those of Stourbridge clay, and Windsor loam, are esteemed the most proper and durable bricks, and they will stand very high degrees of heat without melting. The common potter's clay, which is also employed in the manufacture of bricks, is found to consist of thirty-seven parts of pure argillaceous or clayey earth, and sixty-three parts of siliceous or flinty earth.

Of whatever description the earth intended for bricks may be, it ought to be dug between the beginning of July and the latter end of October, before the first frost appears; it should be repeatedly worked with the spade during the winter, and not formed into bricks till the following spring. If the earth were not used till two or three years after it had been dug, the quality of the bricks would be materially improved; and in all cases, the oftener it is turned, and the more completely it is incorporated, the better will be the bricks.

The clay, before it is put into pits for soaking, must be broken as small as possible, and allowed to lie at least ten days; every stratum of twelve inches should be covered with water, in order that it may be uniformly softened. Two pits, at least, will be necessary for every brick manufactory, so that, after having been suffered to remain for five days, the second may be prepared, and thus the manufacture carried on without interruption. The earth should as much as possible be divested of stony particles, and other extraneous matter, and should have sufficient time to mellow and ferment, otherwise it will be difficult to temper. On the treading and tempering, twice the customary quantity of labour ought to be bestowed. Much of the goodness of bricks depends upon the proper management of its first preparation, for the earth itself, previous to its being wrought possesses very little tenacity; but by long exposure to the air and frost, and thoroughly working and incorporating it together, it is converted into a tough, gluey substance, in which state alone it is fit for moulding.

In the vicinity of London, coal ashes, and in other parts of the country, light sandy earth, is usually mixed with the clay, which, with such addition, is more easily and expeditiously wrought, and requiring rather less fuel, occasions some saving in the expense of burning the bricks; but here the advantages of it terminate; in other respects it is injurious rather than otherwise. If, in tempering the earth, too much water be used, the bricks become dry and brittle; but if duly tempered, they will be smooth, solid, hard, and durable. A brick properly made, requires nearly as much earth as a brick and a half made in the common way, when too great a proportion of water has been added, which tends to render the bricks spongy, light, and full of flaws. As bricks made in the best manner are more solid and ponderous than the common ones, they require a much longer time to dry; they ought not to be burnt till they will give a hollow sound on collision. Proper attention to the drying of bricks is necessary to prevent their cracking and crumbling in the kiln.

Of whatever materials the kiln be constructed, each burning of from six to ten thousand bricks requires the fire to be kept up at least for twenty-four hours, and double that time for a number of from twelve to fifty thousand. The uniform increase of heat deserves particular attention; its duration should be regulated according to the season: in cold weather fire burns most fiercely. During the last twenty-four hours the fire should be uninterruptedly supported by means of flues, but afterwards the fire should not be suddenly closed, as there is always some danger of bursting the flues or melting the bricks.

The following experiment, by Gallon, made with a view to ascertain the difference in the quality of bricks differently manufactured, deserves to be generally known. A certain quantity of the earth prepared for moulding into bricks was taken for the experiment; at the end of seven hours, it was moistened and beaten for the space of thirty minutes. The next morning the same operation was repeated for an equal length of time; in the afternoon it was again beaten for fifteen minutes. Thus this earth had not only been worked for an hour and a quarter longer than usual, but at three different times; the consequence was, that its density was increased; for a brick made of it weighed five pounds eleven ounces, while another brick made in the same mould, of the earth that had not received this preparation, weighed only five pounds seven ounces. The two sorts of bricks were dried in the air, for the space of thirteen days; they were then burnt with others, without any particular precautions, and when they were taken from the kiln, it was found that the bricks made of the earth which had been most worked, still weighed four ounces more than the others, each having lost five ounces by the evaporation of the moisture. They differed also very remarkably in strength, for on placing them with the centre on a sharp edge, and loading the two ends, the bricks formed with the well-tempered earth were not broken with a less weight than sixty-five pounds, or one hundred and thirty pounds in all; while the others were broken with thirty-five pounds at each end, or seventy pounds in the whole. That the quality of bricks should be improved, by bestowing more labour upon the preparation of the earth, will hardly excite surprise, though the degree of the improvement, as just stated, may certainly be considered remarkable; but there is another mode of strengthening these artificial stones, still more extraordinary, and not so easily to be accounted for. Goldham observes, that bricks which have been once burnt, then steeped in water, and burnt again, become doubly strong. We know not that this observation, which is repeated without comment, by nearly all the writers who have occasion to treat of this subject, will always be verified in practice; but it deserves attention, from the number and respectability of the writers who have contributed to give it currency.

The following is a description of the best method of making bricks, with all the improvements that have been introduced within the last few years.

The earth most proper for making the country or kiln-burnt bricks, which, from containing ferruginous particles, always burn red, is a stiff clay, which is tempered alone, formed in moulds, dried in the air and sun, and baked in a kiln like pottery. These sort of bricks are hard and red, sometimes with dark gray or black ends, which, as often seen in our villages, the country bricklayers dispose in various figures of dates, chequer work, and similar forms. They are unfit for cutting and rubbing for gauged work, which is always performed with a milder sort, called *red rubbers*.

The earth selected as the most fit for making common bricks after the London mode, is a clayey loam; and that for the superior sort, such as those which are used for facing buildings, called *malm stock* bricks, is a lighter sort of loam, in which marl is found, frequently met with from two to three feet below the clayey loam.

The earth having been dug in autumn, the workmen are to be employed during the winter in preparing it for the ensuing season. This is done by removing the vegetable mould from the surface, which is called *uncallowing*, and placing coal ashes in proportion of two inches in thickness to every foot deep of earth, which is twelve chaldron of coal ashe, or bereze, as it is called, to every hundred thousand of bricks, and mixing them together in digging the earth; because the composition is improved in proportion as it is exposed and acted upon by the frost, rain, and wind. The mixture is then generally turned over once after it has been dug, but is seldom suffered to remain in this state of preparation longer than one winter before it is used, as it would be inconvenient to the manufacturer from the space it thus occupies; and it is considered not to improve the earth so much as it deteriorates the combustible qualities of the ashes.

When the prepared soil has thus endured a winter's preparation, it is delivered over about Lady-day to the charge of the brickmaker, or *moulder*, as he is called; and the first thing to be attended to in the formation of sound bricks, is tempering the earth. This was formerly done by a gang of six persons, employed and paid by the moulder, who makes them from the heap till laid on the hack to dry by the thousand; and an active, industrious, skilful man can, with these assistants, who are often his wife and children, mould from six to seven thousand in a day, calculating from five o'clock in the morning till eight at night. One of this gang tempered and prepared the earth with a long hoe, by which he pulled it from the heap; a shovel, with which he chopped it backwards and forwards, turning it as often as he found it necessary, incorporating the ashes, sand, and earth thoroughly together; and a wooden scoop, with which he threw water over the mass in preparation, to bring it to a more ductile state. The great difficulty of having this operation, on which so much of the success of the manufacture depends, well performed, has occasioned the introduction into extensive works of machines called *pug-mills*, into which the prepared earth is wheeled after it is mixed with a proper quantity of water. Care should be taken, whether the tempering be done by men or the mill, that too much water be not used, as the more solid the brick is delivered from the mould, the better it retains its form on the hack where it is set to dry; the less it shrinks in drying, the sooner it dries, and the better and more shapely it burns.

When the mass is sufficiently mixed, by either of the above modes, it is laid in small parcels, well kneaded, on the moulding table, which is covered with dry sand. The moulder throws it smartly into the mould, presses it down to fill all the cavity, and strikes off the overplus with a stick previously dipped in water. He then turns the newly formed brick from the mould on to a thin board, larger than the brick, which is removed by a boy to a light latticed wheelbarrow, and is thus conveyed, covered slightly with fine dry sand, to the hacks to dry. The bricks are arranged on the hacks with great regularity one above the other, a little diagonally, in order to give a free passage to the air. In showery weather the piles are usually protected from its injurious effects by some cheap covering, such as straw, or old light boards. In grounds not very extensive, sheds are sometimes erected.

When the bricks are sufficiently dried in the hack, which in fine weather may be in about nine or ten days, they are ready for the fire, which completes the operation. It is of the greatest consequence to the quality of the bricks, that they should be thoroughly dry before they are set in the clamp or stack, which can only be ascertained by breaking a few in halves, selected from various parts of the hack. If the operation of drying in the hack be not thoroughly performed, the bricks will never burn sound; and the moisture which ascends from them in the form of vapour, renders the upper courses in the clamp peculiarly unsound.

The clamps are generally of an oblong form, and contain from one hundred thousand to half a million of bricks. The thickness of the walls should at least be a brick and a half. Bricks are burned in kilns with less fuel, and with greater uniformity and expedition, than in clamps. When they have been set or placed in the kiln, they are covered with pieces of bricks or tiles, and dried by kindling a gentle fire, which is kept up for two or three days, or till the smoke becomes light. More fuel is then added, and the mouth or mouths of the kiln are nearly closed with bricks and wet clay; as soon as the arches of the kiln look white, and the fire begins to appear at the top, they slacken the heat for an hour, and let all cool by degrees. This they continue to do, alternately heating and slacking, till the bricks are thoroughly burnt, which is usually effected in forty-eight hours.

The stacks or clamps are built of the bricks themselves. The foundation is commonly somewhat raised from the surrounding ground, and of an oblong form; the sides slant inwards a little towards the top; hence the clamp, in its figure, is a truncated pyramid. Flues, about the length of a brick in breadth, are made entirely through the clamp; they are about six feet apart when the burning is to be hastened, otherwise they are made about nine feet from each other. The arching of the flues is performed by laying the successive layers of bricks a little over the edge of those below them, till they nearly meet, and then a binding brick at the top finishes the arch. In every direction, the bricks are separated from each other by a stratum of coals and cinders. To facilitate setting fire to the clamp, a quantity of wood is laid with the coal in the flues. When the fire is kindled, if it burn strongly, or the weather is precarious, they plaster the outsides of the clamp with clay, and close the apertures of the flues. On the top of the clamp, a thick layer of breese (cinders) are uniformly laid. When the whole of the fuel is consumed, the manufacturer concludes that the bricks are sufficiently burnt. The operation requires from twenty to thirty days, according to the quantity of fuel, the proximity of the flues, and the state of the weather. When the process has been properly conducted, those in the interior of the clamp are hard, square, and of a good bright colour. These are the stock bricks of the London market.

The preparation of the loam, marl, ooze, chalk, &c. with which the beautiful yellow *malm stock* of London, and the pale bricks of the Ipswich sort, are made, requires more attention, and a longer and more careful process. The earth and other ingredients with which the soil for *malm* bricks are composed, are wheeled into a mill with a due proportion of water. This composition is then ground in the mill, which is supplied with two sets of knives and harrows, and runs out in a state of thick mud or sludge through wooden spouts, into hacks which are raised near the mill. It is there left, till by the water soaking away, and by absorption, it acquires a sufficient consistency or solidity to be kneaded for the moulder. The moulding, drying on the hacks, and burning in the clamps, is performed exactly as before described for common stocks, but with more care and precaution.

As marl is not always to be found where *malm stock* bricks are required, the method used by Mr. Lee, of Lewisham, is so good a substitute, that it is worthy the attention of builders, who may wish to manufacture these beautiful bricks without marl. After many experiments, occasioned by the paucity of marl in the London districts, Mr. Lee discovered that chalk, mixed in certain proportions with the loam, and treated in the usual manner, produced an excellent substitute. For this discovery he took out a patent, which having now expired, this mode of mixing a small quantity of chalk with the brick earth, is generally adopted round London, for the purpose of giving colour and soundness to the brick. At Emsworth, in Hampshire, and at Southampton, ooze or sludge from the sea shore, which contains much saline matter, is used for a similar purpose; but however sound these bricks are, they have neither the rich brimstone colour of the London *malm stock*, nor the regular stone-coloured creamy hue of the Ipswich bricks.

Bricks, like most other useful articles in this country, are subject to a duty, and form an important part of the annual revenue of the government. They are also subject to a regulation as to size. By the 17th Geo. III. cap. 42, all bricks made for sale, shall, when burned, be not less than eight and a half inches long, four wide, and two and a half thick; and by 43 Geo. III. cap. 69, which consolidated the excise duties, every thousand bricks made in Great Britain, not exceeding ten inches long, three inches thick, and five inches wide, are liable to a duty of five shillings; and exceeding these dimensions, to ten shillings.

The principal bricks used in the United Kingdom, are *stock* and *place* bricks, from the *stock* brick clamp: *malm stocks, cutters, seconds,* and *pavers,* from the *malm* clamp. *Red stocks, paving bricks, fire bricks, foot and ten-inch tiles,* from strong clay, and burned in a kiln. Of the *fire bricks,* the best are from Windsor, Stourbridge, Wales, and some of the iron counties. The Welsh are excellent, and will stand extreme heat; they are made of large sizes for the boilers of sugar-houses, brewers' coppers, &c. and are called Welsh lumps.

The place bricks and stocks are used in common walling; the marls are made in the neighbourhood of London; these are very beautiful bricks, of a fine yellow colour, hard, and well burnt, and in every respect superior to the stocks. The finest kind of marl and red bricks are called cutting bricks; they are used in the arches over windows and doors, being rubbed to a centre, and gauged to a height.

An acre of land, including the ashes mixed with the earth, is computed to yield about one million of bricks for every foot in depth. The brick mould is ten inches in length, and three in breadth, and the finished bricks are about nine inches long, four and a half broad, and two and a half thick. Different qualities of earth, however, produce bricks of different dimensions from the same mould; and even the same earth, in proportion as it is more or less wrought or burnt, exhibits similar results.

It is extremely probable that bricks, properly made, would prove superior in durability to almost every kind of stone. In Holland, the streets are every where paved with a hard kind of bricks, known by us under the name of clinkers, which are often imported into this country, and used for paving stables and court yards; and houses in Amsterdam, which have stood more than two centuries, so far from being decayed, appear perfectly fresh as if new.

The numerous patents which have been granted for the making of bricks, appear to have had improvements in the formation of the article for their principal object, without much regard to the materials of which it is composed. Cartwright's patent, the exclusive privilege conferred by which has now expired, is perhaps one of the most important. His improvement consists in giving bricks such a shape or form that they shall mutually lock or cramp each other. The principle of his invention may be understood, by supposing the two opposite sides of a common brick to have a groove or rabbet down the middle, a little more than half the width of the side of the brick in which it is made; there will then be left a shoulder on each side of the groove, each of which shoulders will be nearly equal to one quarter of the width of the side of the brick, or to one-half of the groove or rabbet. A course of these bricks being laid shoulder to shoulder, they will form an indented line of nearly equal divisions; the grooves or rabbets being somewhat wider than the two adjoining shoulders, to allow for mortar, &c. When the next course comes on, the shoulders of the bricks which compose it, will fall into the grooves of the first course; and the shoulders of the first course will fit into the grooves or rabbets of the second, and so on. This configuration of the bricks is to be preferred, as it is perfectly simple; but the principle will be preserved by whatever form of indenture they lock or cramp each other. For the purpose of turning the angles, it may be expedient to have bricks of such a size and shape as to correspond with each wall respectively, though this is not absolutely necessary, as the grooves in the bricks of each wall, where they cross or meet each other, may be levelled, and the bricks lap over as in the common mode. For the purpose of breaking the joints in the depth of the wall, bricks will be required of different lengths, though of the same width. Buildings constructed with bricks of this principle, will require no bond timber, one universal bond running through and connecting the whole building together; the walls of which can neither crack nor bulge out, without breaking through the bricks themselves.

When bricks of this form are used for the construction of arches, the sides of the grooves or rabbets, and the shoulders, should be the radii of the circle of which the intended arch is to be the segment. In forming an arch, the bricks must be coursed across the centre on which the arch is turned, and a grooved side of the bricks must face the workman. It may be expedient, though not absolutely necessary, in laying the first two or three courses at least, to begin at the crown and work downwards. The bricks may be either laid in mortar, or dry, and the interstices afterwards filled and wedged up, by pouring in lime putty, plaster of Paris, grouting, or any other convenient material, at the discretion of the workman or builder. Arches on this principle, it is stated, having no lateral pressure, can neither expand at the foot, nor spring at the crown, consequently they will want no abutments, requiring only perpendicular walls to be let into, or to rest upon; and they will want no incumbent weight upon the crown to prevent their springing up, a circumstance often of great importance in the construction of bridges. Another advantage attending this mode of arching is, that the centres may be struck immediately; so that the same centre (which in no case need be many feet wide, whatever may be the breadth of the arch) may be regularly shifted as the work proceeds. But the greatest and most striking advantage attending this invention, is the absolute security it affords (and at a very reasonable rate) against the possibility of fire; for, from the peculiar properties of this arch, requiring no abutments, it may be laid upon, or let into, common walls, no stronger than what are required for timbers, of which, precluding the necessity, it saves the expense. A more particular account of this invention, illustrated by two plates, may be seen in the third volume of the "Repertory of Arts and Manufactures."

In 1798, Francis Farquharson, of Birmingham, obtained a patent for making bricks and tiles by machinery; and indeed the use of horse power, in working the clay, is now very common.

Whitmore Davis, of Castle Comber, in the county of Kilkenny, Ireland, observed some persons in the vicinity of a colliery, to employ a mortar, for the backs of their grates, which in a short time became very hard. This substance he found, on inquiry, to be what miners term *seat-coal,* or that fossil which lies between coal and the rock. It has been examined by Kirwan, who is of opinion that it will, when mixed with a due proportion of clay, produce a kind of bricks, capable of resisting the action of fire, and consequently well calculated for furnaces, or similar structures. The discovery of the use of this substance is considered important, and it is further observed, that seat-coal, properly prepared, will answer every purpose of tarras, for buildings beneath water.

In building, a considerable waste of time arises from the necessity of making bricks less than the common size, to suit particular situations. Nor is the waste of time the sole loss; in attempting to divide a brick, especially in the direction of its length, one half of it is generally reduced to useless splinters; but bricks have lately been made, which in their soft state were nearly cut through by pressing a wire upon them; they can then be divided by a single blow: a proportion of them, along with the common sort, produces on the whole a saving of some moment.

It is of considerable importance to examine clay before it is made into bricks, in order to ascertain whether any addition can be made to it which will improve its quality. According to the observation of Bergman, the proportion of sand to be used with any clay, must be greater, the more such clay is found to contract in burning, but the best clays are such as require no sand. This illustrious chemist recommends the following mode of analysis to manufacturers: Nitric acid poured upon unburned clay, detects the presence of lime, by producing an effervescence. Calcareous clays, or marls, are often the fittest materials for making bricks. In the next place, a lump of clay, of a given weight, is to be diffused in water by agitation. The sand will subside, and the clay remain suspended.

Paving tiles are a long flat kind of brick, used for laying the floors of kitchens, dairies, cellars, &c. Two or three sizes of them are generally made: the least of English manufacture are about the same length and breadth as common bricks; the largest are about twelve inches square; a middle size, about nine inches square, is also in common use. The thickness of all the sizes of paving tiles is only about an inch and a half. They are made of the strongest kind of clay, and well burnt. Paving tiles or bricks look the best when laid diagonally.

The most common tiles for roofs are those called pan tiles, which are thirteen inches long and eight broad, and about half an inch thick; they are curved in the direction of their length, so that their transverse section is a figure of contrary curvature, like the letter ∽; the hollow of one side serves as a channel for the rain, and for that purpose is made of greater radius than the other, which is employed to overlap the edge of the adjoining tile. The tile at the upper end of its under surface has a knob, by which it is hung to the lath. Tiles constitute a very heavy covering, and require the laths by which they are supported to be proportionately strong. The laths for pan tiles are about three-quarters of an inch thick, and an inch and a quarter broad; they are generally made of deal. The other sorts of tiles are chiefly plain tiles, hip tiles, and ridge tiles; the latter resemble half a hollow cylinder, and are laid on the ridges of houses. Ridge tiles are required by statute to be thirteen inches in length, and six inches and a half in breadth.[*]

In Holland, they frequently glaze their roofing tiles, which increases their durability, but considerably enhances the price of them. The early destruction of unglazed tiles is occasioned by the moisture they imbibe; for when the water has sunk into them, they break with the action of the frost. Sonini has, however, discovered an excellent preventive of this effect, nearly equal to glazing, and very cheap; he directs us to brush over the tiles with tar, after they have been well warmed in the sun. Tiles which have been cracked by the frost, may be preserved from the further influence of the same cause, by the like application.

Of the Tools used in Bricklaying.—The *brick trowel*, which is used for taking up and spreading the mortar, is also used for cutting the bricks to any required size, and should therefore be made of the best steel, and well tempered.

The *hammer* used by the bricklayer, is adapted either to strike a blow, or to divide the bricks, as may be required in cutting a hole through a brick wall, or other operations. One end of the head of it has therefore a face similar to that of any common hammer, and the shape of the other end resembles that of a carpenter's axe, though far narrower in proportion to its length. The handle is inserted much nearer the face of the hammer than the other extremity or edge. Another kind of hammer, often employed in taking down brick-work, differs from the above only in having, instead of the axe part, nearly the shape of an adze, but not so broad for its length; hence it may be driven with facility between bricks to separate them.

The *plumb-rule* is similar to that used by carpenters and other artisans. It consists of a well-seasoned board, the length of which should at least be four feet; its thickness and breadth are not very material, provided they be sufficient to prevent its warping. Down the middle of one of the broad surfaces of the board is drawn a straight line, and at one extremity in this line is attached a small cord with a weight at the lower end. If the long narrow sides of the rule be perfectly straight and parallel with each other, and the line is equidistant from the arris on each side of it, the plummet being hung in this line will form a correct instrument. Either of the long narrow sides of this rule is applied to the wall, so that the plummet and its cord may face the workman, who, by frequently using it, is enabled to carry up his wall perpendicularly. If, in any of these trials, he observes that the cord of the plummet does not coincide with the line on the rule, he sets the bricks further in or out, as may be required to rectify the error, taking care to do it while the mortar they are set in is yet wet. As the plummet is not made to hang below the rule, a hole is cut in the latter, to allow the cord to hang straight.

The *level* employed by the bricklayer, is also similar to that of the carpenter, being of various lengths from six to twelve feet. If one end of the plumb-rule above-mentioned were joined at right angles to the middle of the long narrow edge of another board of the same thickness, but about double its length, it would become a level, the lower edge or side of the piece thus added to the rule, becoming the surface placed on walls, particularly at window sills and wall-plates, to ascertain whether they are horizontal or not. To try the correctness of a level, place it vertically, that is, in the position in which it is used, upon any flat surface, or merely place each end of the bottom edge upon a block of wood, and raise or lower the supports till the cord of the plummet exactly coincides with the line on the perpendicular rule or limb of the instrument. When this is observed, reverse the ends, and if the same coincidence then takes place, the level is true; but if it does not, the bottom must be planed till the trial will succeed. The perpendicular and horizontal parts of the level are not only fastened together by mortise and tenon, but, for greater firmness, and to prevent warping, two braces are added, which extend, in a slanting direction, from the horizontal piece nearly to the top of the perpendicular one.

A *large square* is employed in setting out the sides of buildings at right angles; and a *small square* for trying the bedding of bricks, and squaring the soffits across their breadth.

A *bevel* is required for drawing the soffit line on the face of bricks.

The *rod*, for measuring, is either five or ten feet long; the feet are divided by notches, and one of those next the extremity of the rule is divided into inches. Dimensions may be more expeditiously ascertained with the rod than with a pocket rule; but bricklayers are generally provided with a measuring *tape*, which is coiled up by its winch into a cylindrical box, of such small dimensions, as to unite a more convenient portability than the pocket rule, with greater despatch in the general operations of measurement, than can be obtained by the use of the rod.

The *jointing-rule*, employed in running the joints of brick-work, is eight or ten feet long, and four inches broad. When designed for the use of two bricklayers, the latter length is employed.

The iron tool used along with the jointing-rule, to mark the joints of brick-work, is called a *jointer;* its form is nearly that of the letter S, though its flexure is not in proportion so considerable.

The *raker* has its use designated by its name. It is employed to rake or scrape loose and decayed mortar out of the joints of walls, the appearance of which is intended to be improved by pointing them afresh. The rake is made of iron, pointed with steel, and at about one-fourth of its length from each extremity it is bent to a right angle, so that it would resemble a Z, if the stroke connecting the top and bottom of that letter were perpendicular instead of slanting.

---

[*] *Brick-water*, or water impregnated with the contents of bricks or tiles, is possessed of properties so remarkable, and at the same time so pernicious in their effects, when used for culinary purposes, that we cannot refuse a place to the following curious experiment made by Dr. Percival, and stated in the first volume of his Essays. He steeped two or three pieces of common brick four days in a basin full of distilled water, which he afterwards decanted off, and examined by various chemical tests. It was not miscible with soap; struck a lively green with syrup of violets, became slightly lactescent by the volatile alkali, but entirely milky by the fixed alkali, and by a solution of sugar of lead. No change was produced on it by an infusion of tormentil root. Hence the Doctor justly concluded, that the lining of wells with bricks, a practice very common in various places, is extremely improper, as it cannot fail to render the water hard and unwholesome, equally unfit for the use of the kitchen and wash-house.

The *hod* is an angular wooden trough, closed only at one end; so that it resembles the half of a rectangular box divided in such a manner as to consist of two entire sides and one end, armed with a pole or handle about four feet long. In this utensil, the labourer carries upon his shoulder the bricks and mortar with which he supplies the bricklayer. It is customary to sprinkle the inside of the hod with clean dry sand, before it is filled with mortar, which is thereby prevented from adhering to the wood.

A *cord* or *line*, to serve as a guide in laying the courses of bricks exactly straight, is stretched close to the wall, and removed at the proper intervals as the work advances. This line is fastened to two pointed iron pins, called the *line pins*, one attached to each end of it.

The bricklayer's *rammer*, resembles the pavier's. If the ground intended for a foundation is deemed not sufficiently solid, it is compressed as much as possible by this tool, a due attention to the use of which will prevent fractures that may endanger the building.

The *iron-crow* and the *pick-axe*, are useful assistants to the bricklayer, of obvious utility; being sometimes employed in conjunction, and sometimes alone, in digging, breaking through walls, raising heavy bodies out of the ground, and similar operations.

The *compasses* for traversing arches, and the *grinding-stone* for sharpening tools, scarcely, perhaps, require to be mentioned.

II. *Of Foundations.*—Foundations are either natural or artificial: natural, where the ground is rocky or good, artificial, when, from its boggy sandy state, or from its having been lately dug up, piling, or some other precaution, must be resorted to, for the support of the building. Appearances are so often deceitful, that the prudent builder will never depend upon them, but will examine the ground intended for a foundation with the utmost attention. If the ground shake on being struck with the rammer, the nature of it must be ascertained by piercing it with a well-digger's borer. Having found how far the firm ground is beneath the surface, the loose or soft parts must be removed, if not very deep the excavations made on these occasions: should widen upwards, and their sides be cut in the form of steps; by which means a firmer bed will be obtained for the wall than if the sides of the trenches were simply inclined planes.

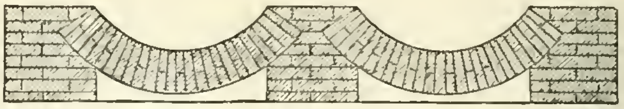
Palladio directs the ground for the foundation to be penetrated to a sixth part of the whole height of the building, unless there be cellars, in which case he recommends digging deeper. It is a good rule to make the foundation double the breadth intended for the superincumbent wall, and the contraction of it should be made alike on both sides.

If the earth is very unsolid, piles, close to each other, and long enough to reach the good ground, must be driven in. The thickness of these piles should not be less than one-twelfth of their length; they should be made to present as even a surface as possible, and should then be covered with planks. It is a curious fact, that dry, straight-grained piles, may be driven much further by the same force, than if they be made of wood in an opposite state.

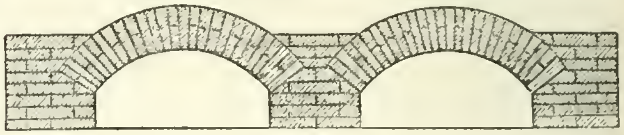
When the infirmity of the ground is uniform, but not very considerable, it may be made good by laying pieces of sound oak about two feet apart, across the breadth of the trench in which the wall is to stand, and when these have been firmly bedded and rammed down, planks of the same timber, or of pitch pine, (which is equally as durable in such situations,) must be laid down and spiked upon them. The planks should be half a foot wider than the base of the foundation wall. Ground of this description may also be made good by ramming large stones upon it closely together, and extending in breadth about a foot on each side of the wall. Upon the first course of stones, another course, rather narrower, may be laid, taking care, as in walling generally, to make the joints of one course fall on the middle of the stones in the other.

If the ground be found defective in one place and good in another, the unequal settlement which would be the inevitable consequence of building upon it in such a state, may be prevented by a plan which is now becoming daily more common, and which, if carefully executed, is always successful. It consists in the use of arches, either inverted or suspended, according to circumstances, which we shall now advert to.

When the soft parts of the ground are under the aperture, only, inverted arches are to be turned under such apertures, in the manner represented by the annexed figure. By this means the advantage of one continued base is obtained, for the piers cannot sink without carrying the arches, and consequently the ground upon which they stand, along with them. The whole building will therefore sink equally, and no fracture of the walls will ensue. So much is the use of inverted arches under apertures approved, that they are considered indispensable in all buildings of considerable weight or consequence, even when the ground is not found to be defective. It is sufficiently obvious, that the walls of all buildings, the base of the foundation of which is not actually laid upon the bare solid rock, will sink a little, and as the pressure of the piers is incomparably greater than that of the low piece of walling under the apertures the risk is extreme, that the resistance of the ground against this low walling will not allow it to sink with the piers, and consequently the fracture of the wall, and probably the breaking of the window sills, will be the consequence. The inverted arches prevent these bad effects; and as they have so important a service to perform, they should be thrown with the greatest care, closely jointed, and their depth at least equal to half their width.



When the reverse of the preceding case occurs, that is, when the solid parts of a foundation are only to be found under apertures, then piers must be built in these places, and arches suspended between them, as represented in the following figure.



It is best to make the middle of the pier rest upon the middle of the summit of the arch. If the pier does not cover the arch, the narrower it is, the greater should be the curvature of the latter at the apex. When arches are used in this way, the intrados ought to be clear, that they may have their full effect. The uniform resistance of the ground upon which the piers are erected, is also of greater importance than even its perfect hardness; for if it resists uniformly, the building will sink in every part alike, and remain uninjured.

When wood is laid in the trench of a foundation, the first course of stone or brick should be laid as close as possible, without mortar, which injures the timber. If there be any difference in the quality of the bricks, the strongest and closest, which are least liable to imbibe moisture, should be selected for foundation work.

III. *Of Cements, Lime, &c.*—The bricklayer being provided with tools, with bricks, and having prepared the trenches of his foundation for walling, finds himself in immediate want of mortar or cement, a subject which next claims our consideration.

The nature and best methods of preparing calcareous cements have been investigated by Dr. Higgins with great ability and success. He has advanced the most satisfactory proofs, founded upon analysis, that the Romans, whose mortar or cement, after a lapse of two thousand years, instead of being decayed, has become as hard as the stones it binds together, possessed no uncommon secret, which we are unable to discover. His publication first appeared in 1780, and is evidently the production of a liberal and intelligent mind. He struck into a path with which we were but little acquainted, though the knowledge of it is of very considerable importance to the public collectively, as well as to individuals; for it is certainly lamentable to observe public or private edifices, insecure, or prematurely mouldering away, from the ignorance or disregard of a few particulars, which might not only be observed with ease, but, in many instances, with a diminution of the original expense. The Doctor's conclusions, which were drawn from innumerable experiments, constitute a great portion of the best part of our knowledge on this subject at the present time; but though so many years have elapsed since they were communicated to the public, they are far from being yet generally known, and consequently are not reduced into general practice.

Such is the neglect shewn on this subject, that the timbers of our houses last longer than the walls, unless the mouldering cement be frequently replaced by pointing. The following directions, for preparing durable mortar or stucco, contain the result of the Doctor's experience, and have been attended to with remarkable success.

Sharp sand free from clay, salts, calcareous, gypseous, or other grains less hard and durable than quartz, is better than any other. When a coarse and a fine sand, corresponding in the size of their grains to the coarse and fine sand hereafter described, cannot be easily obtained native, the following method of sorting and cleansing it must be resorted to. Let the sand be sifted in streaming clear water, through a sieve which will allow all grains not exceeding one-sixteenth of an inch to pass through, and let the stream of water be regulated so as to wash away the very fine parts of the sand, the clay, and every other matter lighter than sand. The coarse rubbish left on the sieve must be rejected. The sand which subsides in the receptacle must then be further cleansed and sorted into two parcels, by the use of a sieve which allows no grains to pass but what are less than one-thirteenth of an inch in diameter. That part which passes through this sieve, we shall call fine sand, the remaining portion, coarse sand. These separate portions may then be dried in the sun, or by means of a fire.

That sort of lime must be chosen which heats the most in slaking, and slakes the quickest when duly watered; which is the freshest made, and has been the closest kept, which dissolves in distilled vinegar with the least effervescence, and leaves the smallest residue insoluble, and in this residue the smallest quantity of clay, gypsum, or martial matter. Put fourteen pounds of the lime chosen according to these important rules, into a brass wire sieve still finer than the last mentioned. Slake the lime by alternately plunging it into and raising it out of a butt of soft water; reject all the matter which does not easily pass through the sieve, and use fresh portions of lime in a similar manner, until as many ounces of lime have passed through the sieve as there are quarts of water in the butt. This is the lime-water, which contributes materially to the excellence of the stucco. As soon as a sufficient portion of lime has been imparted to it, it should be closely covered until it becomes clear, and then be drawn off, by wooden cocks, placed at different heights as the lime subsides, without breaking the crust formed on the surface. The freer the water is from saline matter, the better will this liquor be. Lime-water must be kept in air-tight vessels till the moment it is used.

Slake fifty-six pounds of lime chosen as above directed, by gradually sprinkling on it the lime water. Sift the slaked part of the lime immediately through the last mentioned fine brass-wire sieve; the lime which passes must be used instantly, or kept in air-tight vessels, and the rest rejected. This finer, richer part of the lime may be called purified lime. It is always advisable to sift the lime *immediately* after the slaking, otherwise much of the ill-burnt lime and heterogeneous matter which it may contain, will pass through the sieve.

The materials of the cement being thus prepared, take fifty-six pounds of the coarse sand, and forty-two pounds of the fine sand; mix them on a large plank of hard wood placed horizontally; then spread the sand so that it may stand to the height of six inches with a flat surface on the plank, and wet it with lime-water, of which so much must be allowed to flow away off the plank, as the sand in the condition described cannot retain. To the wetted sand add fourteen pounds of the purified lime in several successive portions, mixing and beating them up together with the instruments generally used in making fine mortar. Then add fourteen pounds of bone-ashes in successive portions, mixing and beating all together. The quicker and more perfectly these materials are mixed and beaten together, and the sooner the cement thus formed is used, the better it will be. As this cement is shorter than water or common stucco, and dries sooner, it ought to be worked expeditiously in all cases, and in stuccoing it ought to be laid on by sliding the trowel upwards on it. The materials used along with it in building, or the ground on which it is laid in stuccoing, ought to be well wetted with the lime-water at the instant of laying it on; and when the cement requires moistening, lime-water should always be used.

The proportions above given are intended for a cement made with sharp sand, for incrustation in exposed situations, where it is necessary to guard against the effects of hot weather and rain. In general, half this quantity of bone-ashes will be found sufficient; and although the incrustation in this latter case will not harden deeply so soon, it will be ultimately stronger, provided the weather be favourable.

When a mortar or cement of a fine texture is required, take ninety-eight pounds of the fine sand: wet it with the lime-water, and mix it with the purified lime and the bone-ashes in the quantities and in the manner above described, with this difference only, that fifteen pounds or thereabouts of lime are to be used instead of fourteen pounds, if the greater part of the sand be very fine. This cement is suitable for the last coating of any work intended to imitate the finer grained stones; but it may be applied to all the uses of the first mentioned composition.

When a mortar or cement is required, which shall be still cheaper and more coarsely grained, much coarser sand than the coarsest sort already spoken of may be made use of; for the coarser the sand, the less the proportion of lime which will be required. For example, of the coarsest sand alluded to, take fifty-six pounds; of the coarse sand which passes through the meshes of a sieve one-sixteenth of an inch in diameter, twenty-eight pounds; and of the fine sand, fourteen pounds; and after mixing these, and wetting them with lime-water, in the manner already described, add fourteen pounds, or somewhat less, of the purified lime, and then fourteen pounds or somewhat less of the bone-ash.

When these cements are intended to be white, white sand, white lime, and the whitest bone-ash, are to be chosen. Gray sand, and gray bone-ash, formed of half-burnt bones, are to be chosen to make the cement gray; and any other colour may be obtained either by choosing coloured sand, or by the admixture of the necessary quantity of coloured talc in powder, or of coloured vitreous or metallic powders, or other ingredients of a similar nature.

These cements are applicable in forming artificial stone, by making alternate layers of the cement and of flint, hard stone, or brick, in moulds of the figure of the intended stone; the stones thus formed being exposed to the open air to harden, but not exposed to rain till they are almost as strong as fresh Portland stone. They may be made very hard, and beautiful, by soaking them, after they are thoroughly dry, in the lime-water, and repeating this process several times at distant intervals. Incrustations, also, are greatly benefited by the application of lime-water, the entrance of which is facilitated by the use of bone-ashes in the cement.

When any of the above cements are intended to be used for water-fences, two-thirds of the prescribed quantity of bone-ashes are to be omitted, and an equal measure of powdered terras used instead; and if the sand employed be not of the coarsest sort, more terras must be added, so that the terras shall be by weight one-sixth part of the weight of the sand.

When a cement is required of the finest grain, or in a fluid form, so that it may be applied with a brush, for the purpose of smoothing and finishing the stronger crustaceous works, or for washing walls to a lively and uniform colour, the fine powder of calcined flints, or the powder of any quartzose or hard earthy substance, may be used in the place of sand; but in a quantity smaller as the flint or other powder is finer; so that the powder shall not be more than six times the weight of the lime, nor less than four times its weight. The greater the quantity of lime within these limits, the more the cement will be apt to crack by quick drying, and *vice versa*. For washing walls, the cement should not be made thicker than new cream, and should be laid on briskly with a brush, in dry weather. Fine yellow ochre is the cheapest colouring ingredient for such a wash, when it is required to imitate Bath stone, or the warmer white stones.

Where sand cannot be procured, any durable stony body, or baked earth grossly powdered, and sorted as if it were sand, may be used, measure for measure, but not weight for weight, unless the same bulk of the gross powder be the same as that of sand. But all substitutes for pure siliceous sand, are imperfect in proportion as the particles of which they are composed, are less hard than those of that material. The scrapings of roads, which consist principally of powdered calcareous stone, the old mortar and other rubbish from ancient buildings, have often been more strongly recommended than they deserve. These, and all muddy, soft, and minutely divided matters, require a large proportion of lime, and never possess the hardness and durability which belong to good mortar. Sea sand, well washed in fresh water, is as good as any other *round* sand; but if used without being freed from salt, the mortar made with it is extremely liable to be damp.

The proportion of lime may be increased without inconvenience, when the cement or stucco is to be applied where it is not liable to dry quickly; and in the contrary circumstance, this proportion may be diminished. The defect of lime in quantity or quality, is best supplied by soaking the work, at distant intervals of time, with lime-water. It is proper to mix hair with these cements, when employed for interior work.

The power of almost every well dried or burnt animal substance may be used instead of bone-ash.

The bone-ashes facilitate the operation of plastering, by increasing the plasticity of the mortar into which they enter. They also render the mortar less liable to crack, and cause it to acquire more quickly that state in which it is not easily injured by unexpected rain. If employed in a less proportion than one-fourth of the lime, they are of little use, and if they exceed the lime in quantity they are injurious to the cement. Hence the use of them should be regulated according to the following circumstances: when the artist is more solicitous to secure an incrustation from the effect of hot weather, to finish it quickly, and to guard against rain, than to make it durable in the highest degree, he may use as much bone-ashes as lime; but when the season, exposure, and other circumstances, permit him to attend solely to the true excellence and duration of his work, he must use, in his best calcareous cements, only one part of bone-ashes for every four parts of lime. By these rules he may choose intermediate quantities adapted to his purposes. The bone-ashes should not be in so coarse a powder as they are when used for cupels, yet they should by no means be levigated or ground to extreme fineness.

By *sharp* sand, is meant such sand as consists of grains with flat surfaces; these flat surfaces, when enveloped and cemented together by the lime paste, possess a much stronger cohesion than if the grains were globular.

The preceding method of making mortar or stucco differs, it will be perceived, from the common process in several essential particulars; among which, the purity and sorting of the sand, the use of lime-water, the newness of the lime, and the large proportion of the sand to the lime, ought to be particularly noticed. It may be useful to inquire into some of the causes of differences of practice so remarkable.

When the sand contains much clay, or other impurities, the bricklayers find that the best mortar they can make, must contain about one-half lime; and in consequence pronounce, without further investigation, half sand and half lime to be the best composition. But with sand requiring so much lime, they never can make durable mortar, though of this fact it may be difficult to convince those who are little disposed to investigate causes. Too many artisans entertain an opinion that they have nothing new to learn which is worth notice; they are apt in effect to say, that having served an apprenticeship to their business they *ought* to know *something;* and thus, because they *ought to know something*, they seem to expect submission to their very errors. To such characters we speak not; to convince them is impossible, and therefore the attempt is folly. But those who consider the interest of their employers, and that the warmth, dryness, and salubrity of a house, so far as the building is concerned, is completely in their power, will not despise any hint which may extend their resources.

It is a common fault to build lime-kilns so high, that, at the bottom of the cavity, the lime is ready perhaps eighteen hours before that in the upper part, and is greatly injured by its exposure to the draft of air passing through the fire. Lime-kilns ought to be made much broader and shallower than customary, with the cavity tapering upwards, and should terminate in a lofty flue, in order to accelerate the combustion, when required, by a quick current of air. Calcareous stones acquire in the most eminent degree the properties of lime, when they are slowly heated in small fragments of uniform size, until they appear to glow with a white heat, and this is continued until they become non-effervescent if steeped in an acid. The art of preparing lime consists chiefly in attending to these particulars. The whiteness of lime shews it to be free from metallic impregnation. Merely to keep lime dry is not enough to preserve it; it grows worse for mortar every day it is kept in heaps or untight casks, and is soon reduced nearly to the state of chalk. It may be greatly debased, without slaking sensibly, and such parts or fragments as fall to powder merely by exposure to the air are unfit for mortar. It has been found by experiment, that lime will absorb one-fourth of its weight of water, and yet remain perfectly dry. Bishop Watson found, that, upon an average, every ton of limestone produced eleven hundred weight, one quarter, and four pounds, of lime, weighed before it was cold; and that, when exposed to the air, it increased in weight daily, at the rate of a hundred weight per ton, for the first five or six days after it was drawn from the kiln. Hence those who have to fetch lime from great distances, may save even in point of cartage, by receiving it as it is taken out of the kiln.

Mortar which sets without cracking, whether this be owing to the due proportion of sand, or to the slow exhalation of the water from mortar containing less sand, never cracks afterwards, whatever its faults, in other respects, may be. As it is the lime paste, and not the sand, which contracts and produces fissures in drying, so the more sand there is in the composition, the less the cracks will be seen. Mortar which is liable to crack, becomes irreparably injured by frequent alternations of wetting and freezing; for the water imbibed by the smallest fissures, dilating as it congeals, loosens its whole texture. Where it is composed of seven parts of sorted sand to one of lime, it is not disposed to crack.

That mortar may become indurated the soonest and in the highest degree, and operate the most effectually as a cement, it must be suffered to dry gently and set; the exsiccation of it must be effected by temperate air, and not accelerated by the heat of the sun or fire. It must not be wetted till after it sets; and afterwards it ought to be protected from wet as much as possible, until it is completely indurated; the absorption of carbonic acid must be prevented as much as possible till the mortar is finally placed and quiescent, and then it must be as freely exposed to the open air as the work will admit, in order to supply carbonic acid, and enable it sooner to sustain the trials to which mortar is exposed in cementitious buildings and incrustations. To shew more clearly how much our slight buildings are weakened by the agitations and percussions to which they are exposed, first in erecting the walls and settling the timbers, and then in driving those wedges to which the wainscots, mantle-pieces, and other ornaments, are fastened, we must observe, that the absorption of carbonic acid by mortar contributes nothing to the strength of it, if it enter before it is finally fixed in a quiescent state. A little experience is sufficient to teach us, that the same matter which assists in the induration of mortar, never serves to repair the fissures, or solution of continuity between the bricks and cement, which happens after it is set. When mortar is set, and before it is indurated, it may be easily severed from the bricks and crumbled; and for want of softness, it cannot bend into the fissures, or resume its former condition in any time. Hence by heavy blows, and in wedging, our walls must be greatly weakened; and the more so, as the houses are slight, quickly built, and hastily finished.

Nothing is more common than for bricklayers to keep their mortar some time exposed to the air in heaps, before they consider it proper for use; a practice which may perhaps be accounted for, if we consider that some portions of every kind of lime used in this country, do not slake freely, by reason of their not being sufficiently burned, or of the admixture of gypseous or argillaceous matter; which portions, like marl, slake in time, though not so quickly as the purer lime. The plasterers, who use a finer kind of mortar, made of sand and lime, observe that their stucco blisters, if it contain small bits of unslaked lime, and as smoothness of surface is with them of more consequence than excessive hardness, they take care to secure the perfect slaking of their lime by allowing sufficient time for the imperfect parts to be penetrated by the moisture. The bricklayers, trusting, perhaps, more to the judgment of the plasterers, in this respect, than to their own, and considering it very convenient to slake a large quantity of lime at once, follow the same practice, without caring for or apprehending the real fact, that mortar is worse for every hour it is kept, and that they are taking such measures as will prevent it from ever acquiring that degree of hardness in which its perfection consists.

Among the circumstances which contribute to the speedy ruin of modern buildings, it may also be observed, that mortar made with bad lime, and a great excess of it, is used with dry bricks, and not unfrequently with warm ones. These immediately imbibe or dissipate much of the water, and as the cement approaches nearer to be dry, whilst it is still liable to be displaced by the percussions of the workmen, render it little better than equivalent to a mixture of sand and powdered chalk. To make strong work, the bricks ought to be soaked in lime-water, and freed from the dust with which they are commonly covered. By this means the bricks are rendered closer and harder, the cement, by setting slowly, admits the motion which the bricks receive when the workman dresses them, without being impaired, and it adheres and indurates more perfectly. This steeping of the bricks is an imitation of the practice of the plasterers, who always wet the wall before they commence their work, because they know the cement will not otherwise adhere. This ought to be done as long as the wall is thirsty, and lime-water is the most proper liquid they can use. The same advantage that attends the soaking of bricks, would attend the soaking of bibulous stones in lime-water.

Mortar made with sand containing one-seventh or one-eighth of fat clay, moulders in winter like marl; a circumstance which proves the propriety of freeing from clay the sand used in mortar. The washing performed for this purpose, will be found a very cheap operation, even in cities, if the water which carries off the clay be directed into a receptacle where it may be depurated by subsidence for repeated use.

Chalk lime may be easily prepared, so as to be fully equal if not superior to stone lime. The reason why this is not generally thought to be the case, probably is, that not being of so close a texture, it is sooner spoiled by the absorption of carbonic acid, when exposed to the atmosphere after it is made. A cask of chalk lime should therefore never be opened till the moment it is to be slaked, and the greatest expedition should be used in the slaking, and in the making and applying the mortar to use. In the quiescent air of a room, a pound avoirdupois of chalk lime becomes two ounces and a half heavier in two days; and nearly the whole of this increase of weight consists of the carbonic acid which it has imbibed from the atmosphere.

The fittest water for making mortar, is rain water; river water holds the next place; land water the next; spring water the last; sea water, and all waters noticed medicinally or otherwise, for their saline contents, ought never to be used for this purpose.

The compositions mostly used for stuccoing within doors, are incapable of hardening considerably, and when they are laid on the naked walls, soon become tarnished, unsightly, and inconvenient, by the damps which workmen call sweating. Sometimes these damps are occasioned by the bad construction of the walls, the joints of the facing bricks having become hollow by the decay of the mortar, or when the copings or gutters are defective: a damp by transpiration also occurs when the principal walls are stuccoed before they are dried, or when the materials of them are so spongy as to imbibe the rain, and the circulation of air is not sufficient to waft away the transuding moisture. The damp by condensation is also very common, and appears most on the closest incrustations, however perfect and old the walls may be. In such instances, the damp is owing to the closeness of the body, and a stucco pervious in a certain degree to air and moisture, will be free from it, as well as from the damp before mentioned. The customary mode of avoiding these damps, is to case the principal walls of houses with lathwork, on which the incrustation or plaster is laid at some distance from the wall. The narrowing of rooms and passages very perceptibly is the consequence of this method, besides its expense. Bone-ashes, each grain of which is tubulated is every direction, added to the stucco in half the quantity of the lime, are a preventive of these damps without lathwork.

The drying, induration, and texture of incrustations made on brick walls and other irregular surfaces, are always so far unequal as to exhibit visible traces which deform the work, and cannot be effectually obliterated by any known method so convenient as that of covering the first coarse incrustation, after it has dried, with another coat which may be made finer and smoother. Thus the expense of fine-grained, smooth, or coloured stucco, is rendered moderate; because the finer, or the colouring ingredients, may be reserved for the exterior coat, which will last for ages, if the cement be good.

To tinge a cement sufficiently, of any colour which is not found in sand, so that the incrustation shall not be impaired, and that the colour shall be as durable as the cement, the most proper ingredients which can be used in lieu of sand, or of part of it, are coloured glasses or coloured stones of the hardest kind, beaten to coarse powder; the finer parts of which are to be washed away, not merely because they are injurious to the cement, but because they contribute very little to the intended colour.

Stucco made with the best proportions of lime, sand, and lime-water, is not bettered by painting as soon as it dries; as this covering retards the induration of it, by cutting off its communication with the air. It therefore renders it liable to be irreparably injured in wet weather, wherever the water can get behind the paint. If paint or oil ought ever to be applied on such stucco, it ought not to be laid on in less than a year after the incrustation is made. The painting and sanding of the common defective incrustations, contribute very little to their duration, although it hardens them at the surface; for it does not effectually prevent them from cracking, and it avails very little to paint the cracked stucco again, because cracked stucco is always hollow, as the workmen term it; that is, it parts from the wall in the parts contiguous to the cracks, sounds hollow on being struck with the knuckle, and falls off in a few years, if it be so thick and large in extent as to break the adhering portions by its weight.

Mortar made of sand, water, and lime, whatever may be the proportions of the mixture, cannot be employed in aqueducts, reservoirs, and other aquatic buildings, unless sufficient time be allowed for its perfect induration before the admission of the water; but when mixed up with a quantity of terras, as already stated, it acquires the desirable property of hardening under water. A few additional remarks on this subject will perhaps be acceptable. A mortar made of terras powder and lime was used in water-fences by the Romans, and has been generally employed in such structures ever since their time. As it sets quickly, and when set is impenetrable to water, some people have hastily concluded that it is the best kind of mortar for any purpose. But it is found by experience, that mortar made of terras powder, whether coarse or fine, will not grow so hard as mortar made with lime and sand, nor endure the weather so well; on the contrary, it is apt to crack and perish in the open air. Its efficacy in water-fences is experienced only where it is always kept wet, and seems to depend principally upon the property which the powder of terras has, in common with other argillaceous bodies, but in a higher degree, of expediting the crystallization of the calcareous matter, by imbibing the water in which it is diffused in the mortar, and of swelling during this absorption, so much as to render the mortar impenetrable to any more water. It seems, also, that an acid of the vitriolic kind, which is contained in terras, contributes to the speedy setting of the cement, by reducing a part of the lime to the condition of gypsum. Terras is a volcanic production, consisting chiefly of clay and oxide of iron indurated together; and baked clay, reduced to powder, communicates to mortar properties of a similar kind.

Pozzolana is another volcanic production differing little from terras, as to the effect it produces in mortar. It is thrown out of volcanoes in the form of ashes, and is found in many countries, but most abundantly in the kingdom of Naples. The cement used by Smeaton, in the construction of the Eddystone light-house, was composed of equal parts by measure of lime and pozzolana; a mixture which was deemed the most suitable, as the building was exposed to the utmost violence of the sea; but a composition exceedingly proper for aquatic works in general, may be composed of two parts of lime, one of pozzolana, and three of clean sand.

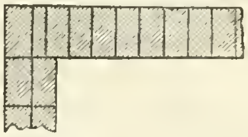
It has lately been discovered, that manganese is a valuable ingredient in water-cements, if used in the following manner; mix together four parts of gray clay, six of the black oxide of manganese, and ninety of good limestone reduced to fine powder; then calcine the whole to expel the carbonic acid. When this mixture has been well calcined and cooled, it is to be worked into the consistence of a soft paste with sixty parts of washed sand. If a lump of this cement be thrown into water, it will harden immediately.

IV. *Of Brick Bond and Walling.*—When a brick is laid so that its length is in the direction of the length of the wall, it is called a *stretcher*; and when its length crosses that of the wall, it is called a *header*.

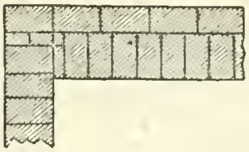
The term *bond* is applied to any disposition of the bricks, by which the continuity, in a straight line, of the joints of a wall is interrupted. It is obvious that a bond may be adopted, which will interrupt the rectilinear direction of both the horizontal and vertical joints of a wall; but in the two kinds of bond which have hitherto prevailed, the horizontal joints are continued in the same line round the whole building, and the vertical ones only interrupted. When the wall is only intended to be half a brick, or four inches and a half in thickness, the whole of the bricks are laid so as to form stretchers, that is, their length is laid in the direction of the length of the wall, and the bond is obtained simply by making the vertical joints in every course exactly opposite the middle of the bricks above and below. But when the wall is intended to be the length of a brick or more in thickness, it would be apt to split into parts if it consisted only of two or more walls separately bonded, as in the instance just mentioned of the half brick wall. The bricks, therefore, in thick walls, must be connected in their breadth as well as their length, and this is done according to two principal modes, one of which is called English, the other Flemish bond.

English bond consists of headers and stretchers crossing each other in separate horizontal courses. In Flemish bond, the headers and stretchers are placed alternately in the same horizontal course. Flemish bond is now so common, that hardly any other kind is to be seen; it is preferred, for its appearance, to the English, which is much superior in point of strength, and in facility of execution. Many attempts have been made to unite Flemish facings with complete bond, but without success. Some have laid thin slips of iron occasionally in the horizontal joints between the two courses; and others have laid diagonal courses of bricks in the core of thick walls, so as to cross each other at right angles in successive courses. By the latter means, though the bricks in the middle of the core have a strong bond, yet as they form triangular interstices with the bricks on each side, the bond of the whole wall is very incomplete. As the adjustment of the bricks in one course must depend on the course beneath, the latter, in making the Flemish bond, must be seen or recollected by the workman. The view of the joints of the under course is hindered by the mortar with which they are covered, to bed the bricks of the succeeding course upon, and it is perplexing for the workman to recollect the arrangement of them, so that he is in danger of making the joints frequently to correspond, and thus rendering the bond imperfect. In the old English bond, the outside of each course points out the proper disposition of the next, so that it is an easy matter for the workman to avoid error.

The following plans of walls in English bond, which well deserve to be revived in this country, will render this subject more intelligible:



The annexed figure represents the bond of a nine-inch wall. In order that two vertical joints may not run over each other, at the end of the first stretcher from the corner, after placing the return corner stretcher, which becomes a header in the face that the stretcher is in below, half the length of which it covers, a half brick is placed on its side, so that with the return corner stretcher, it extends six inches and three-quarters, and thus a lap of two inches and a quarter is obtained for the next header; and the bond is continued by working up the wall with alternate rows of headers and stretchers mutually crossing each other. The half brick, or brickbat, thus introduced, is called a *closer*, and must be divided, it will be understood, through its two broadest surfaces, in the direction of their length. The same effect might be obtained by the introduction of a three-quarter brick at the corner of the stretching course, for then when the corner header is laid over it, a lap of two inches and a quarter will be left at the end of the stretchers below for the next header, the middle of which, when laid, will be over the joint below the stretcher, and thus constitute a bond as before. The brick for the three-quarter bat, or closer, must be divided through its two broadest surfaces, in the direction of their breadth.



The English bond of a brick and a half, or fourteen-inch wall, appears in this figure. Here the stretching course is so disposed, that the middle of the breadth of the bricks in the same layer or level, falls alternately upon the middle of the stretchers, and upon the joints between the stretchers.

The English bond of a two-brick wall, fig. 1. To break the joints in the core of the wall, every alternate header, in the heading course, is only half a brick thick. The English bond of a wall two bricks and a half in thickness, fig. 2. The disposition of the bricks is similar to that of those in fig. 1.

Fig. 1.

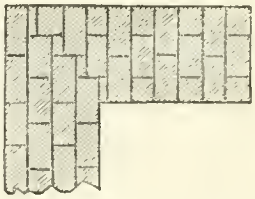
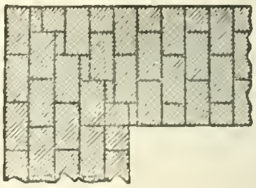


Fig. 2.



Part of the front of a wall in English bond, fig. 3, the unbroken side being the corner. The Flemish bond of a nine-inch wall, fig. 4. Two stretchers lie between two headers; and bricks being twice as long as they are broad, the breadth of the two stretchers is equal to the length of the header, which is the whole thickness of the wall. The dotted lines shew the disposition of the bricks in the second course.

Fig. 3.

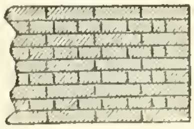
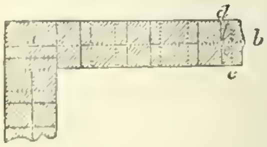


Fig. 4.



The Flemish bond of a brick and a half or fourteen-inch wall, fig. 5. On one side the bricks are laid as in fig. 4, and on the other side, half headers are placed opposite the middle of the stretchers, and the middle of the stretchers opposite the middle of the end of the headers. Fig. 6, another example of Flemish bond, for a wall of the same thickness as the last. Here the disposition of the bricks is alike on both sides of the wall, the tail of the headers being placed contiguous to each other, an arrangement that produces, in the core of the wall, square spaces, which must be filled with half bricks. Fig. 7, part of the front of a wall in Flemish bond, reaching on one side to the corner.

Fig. 5.

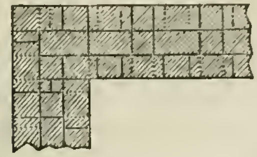


Fig. 6.

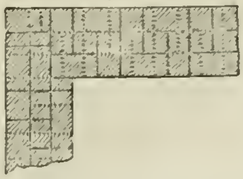


Fig. 7.

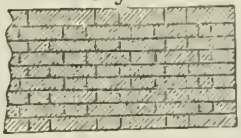


Fig. 1, 2, 3, and 4, in the following engraving, exhibit plans of brick piers in Flemish bond. No. 1, in each figure shews the bottom course, and No. 2 the upper course; or, which amounts to the same thing, No. 2 may be considered the lower course, and No. 1 will then be the upper one.

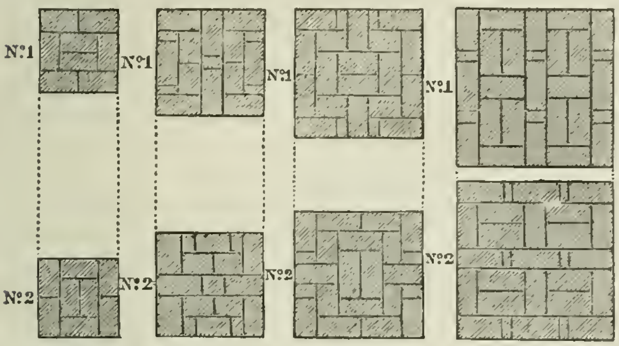


Fig. 1, is a pier, two bricks, that is, eighteen inches, square; for in speaking of the thickness of a wall or pier as consisting of so many bricks, the length of a brick is always to be understood. Fig. 2, a two and a half brick pier. Fig. 3, a pier three bricks square. Fig. 4, a pier three bricks and a half square.

Before we take leave of the subject of bond, we must remark, that a patent has within a few years been taken out, by Moore and Co. of London, for a vertical bond, which is intended to supersede the use of the bond timbers introduced to secure the equal settlement of the wall. In case of fire, when the bond timbers of a house are consumed, the falling of the wall almost necessarily follows. The patentees, therefore, instead of these timbers, place rows of hard strong bricks perpendicularly in the middle of their walls, at short distances from each other in height as well as horizontal measurement, and they place each row of the perpendicular bricks in such a manner, as to be opposite the middle of the space between the row standing in the same position immediately above or below it. This plan for obtaining a vertical bond seems new and ingenious, and is applicable, as indeed the patentees observe, to stone walls, as well as to those of brick.

The following figure represents a straight arch, which is usually made the height of four courses of brick; but in considerable buildings, it may with great propriety be made the height of five courses. The manner of drawing the joints of a straight arch will be evident from an inspection of the figure. The joints of the arch-stones must all be made to lie in a direct one to the point C. The point C is easily obtained, as it is as far from the points A and B,) which are separated by the whole breadth of the aperture,) as A and B are from each other. Hence the lines connecting A, B, and C, form an equilateral triangle. To key the arch in, it is usual to have a brick, and not the joint between two bricks, in the centre; and therefore the division of the arch must be managed accordingly. Though the brick in the middle tapers more in the same length than the extreme bricks, yet as the difference is very small, it is disregarded, from the great convenience of drawing all the bricks with the same mould. It may, however, be observed, that the real taper of the mould may be a medium between that required for the middle and that for either extreme distance. But whether this be done or not, the defect will not appear in practice.

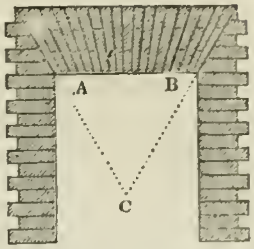


Fig. 1, a scheme arch, one brick, that is, nine inches high. Fig. 2, a semicircular arch, one brick high.

Fig. 1.

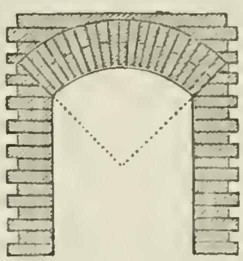
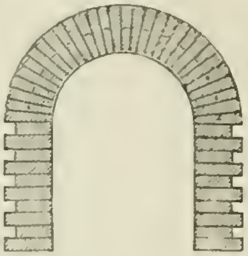
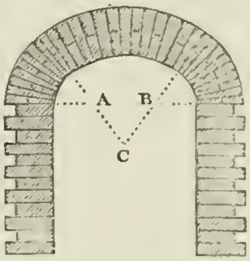


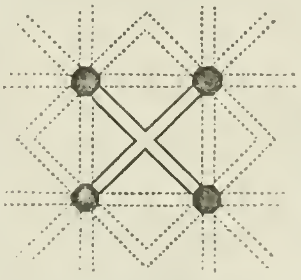
Fig. 2.



The subjoined figure is an elliptical arch, one brick high, the top of which is divided into equal parts, and not the under side. It is struck from three centres, A, B, and C.



The arches delineated in the last three figures are often made a brick and a half, or even two bricks high; but for crowning the apertures of ordinary dwellings, the height of one brick is deemed sufficient, both for stability and appearance. In arches of one brick high, when the walls are only half a brick thick, it is evident there is no necessity for joints following the course of the arch in every alternate brick. Accordingly, these joints, in such walls, are generally false ones, being merely nicks of little depth cut with the tin-saw; and are made as a kind of decoration, in arches exposed to view, to give, when pointed along with the other joints, a more lively appearance. But when the walls are of one brick or a greater thickness, the joints in question must be real, and formed of two bricks disposed as headers, for the sake of bond.



This figure is a plan of Tapper's improved method of groining. The improvement consists in raising the angles from an octagonal pier instead of a square one. By this means, the angles of the groins are strengthened by carrying the band round the diagonals of equal breadth, thus affording better bond to the bricks, which are usually so much cut away, that instead of giving support, they are themselves supported by the adjacent filling-in arches. Square piers are very inconvenient in cellars, by hindering the turning of goods round their angles.

In different parts of the country, it will naturall. be supposed that many differences of practice will prevail in the details of building. Several of these differences originate in local peculiarities of materials, of one kind or another; but there is one, not belonging to this class, respecting which we might have expected to find a very general uniformity of practice. In London, and a wide district around, the scaffolding for the workmen, in erecting the walls of a building, is external; but in Liverpool, and several other parts of Lancashire, and adjacent counties, the scaffolding is wholly within the building, whatever may be its size or consequence. On the merits of either plan we shall not offer a decisive opinion; yet we may remark, that external scaffolding is not only the most expensive, but has an air of insecurity to the workman, and of incompactness, which is unpleasant to the observer, especially when he is aware that such cumbersome appurtenances may be dispensed with. In populous towns, or confined places, also, the encroachment of external scaffolding upon the street, is not a trifling inconvenience, particularly as the bricks and other materials must be at some distance beyond its limits, to prevent accidents. Interior scaffolding, on the contrary, being supported on the joists of each floor as the work proceeds, is erected with little trouble or expense, the workman marks his joints with as much ease and regularity as if he were at the outside, such a thing as a falling brick or splinter is hardly known, and the bricks and other materials may, if necessary, be laid close to the wall, so as to occasion little inconvenience in the street.

To obtain the desirable requisite of dry walls, we have already observed, that the usual resort is the use of interior lathwork, and have adverted to the means of preventing this expense, by a proper composition of the mortar or stucco. Another expedient in common use, intended to secure the dryness of the walls when lathwork is deemed too expensive, consists in leaving a portion of the bricks in the core or middle of the walls, without mortar from the top to the bottom. The interstices thus left, serve, in some measure, the same purpose as the space between the lathwork and the bricks. Perhaps the reference to a figure may make the nature of the plan more easily apprehended. In the nine-inch wall, in the elliptical arch, the longitudinal joint *a b*, and the middle third, or from *e* to *f*, of the transverse joint *c d*, would be left without mortar; and the same thing is done to all the other joints or portions of joints similarly situated. By this contrivance, the bond of the wall is greatly weakened; but strength, it will be perceived, is not the object of it; the walls in the inside are drier, they look as well, the house will let for as high a rent as a stronger, and its instability is left for the purchaser, or the next generation, to discover. It has not unfrequently happened, however, that the slightness of modern houses has been quickly proved, by their having tumbled down before they were even finished. There is one advantage of casing external walls with lathwork, which is independent of damp, and therefore not the object, though the consequence, of that operation. As air is one of the most imperfect conductors of heat known, the column of it included between the plaster or stucco and the bricks, tends to prevent the temperature of apartments from being affected by sudden vicissitudes in the heat of the external atmosphere. Lathwork casing should be composed of well-seasoned heart laths, as the sap laths will shrink. Reeds are used instead of laths in some parts of the country: but they require a greater quantity of mortar than laths, and produce on the whole little or no saving.

Frost is exceedingly prejudicial to new brick-work, and its effects ought to be guarded against with the utmost care. When it is apprehended, the wall should not be left uncovered at night; a capping of straw or of weather-boarding formed like the roof of a house, to carry off the rain equally on both sides, if any occur, is generally employed; and sometimes for the more complete security, both the straw and the boarding are employed at the same time, the straw being placed next the wall. In winter, the mortar should be used stiffer than at other seasons, and if a quantity of lime, which is quite fresh, or has been kept in tight casks till it is wanted, were reduced to powder without slaking, and well beat up with it, the setting of it would be very materially hastened. Where strong work is required, it is not expedient, even in winter, to relinquish the practice already recommended, of steeping the bricks in lime-water; and when this is done, the method just mentioned of preparing the mortar is the more useful. The bricks should not, however, be laid so dripping wet in winter as in warm dry weather. When the practice of steeping the bricks in lime-water is rejected as too troublesome, the sprinkling of each course with common water may be considered the easiest substitute for that operation. This method of strengthening the work was adopted in the building of the College of Physicians, London, at the judicious suggestion of Dr. Hooke.

If the mortar has been suffered to lie any time, previous to its being used, the labourer should beat it up again to give it tenacity, and to prevent the bricklayer from losing time in working it with his trowel.

In working up the wall, it is by no means advisable to work more than four or five feet in height at a time; for as all walls shrink a little soon after building, if the different parts of the circuit of the walls or carcass be carried up at distant intervals, one part will sink by itself, and will consequently separate from the other part which has become fixed. No portion of a wall ought to be carried up more than the height of one scaffold above the rest, except in some case of pressing emergency. In carrying up any particular part, each side on the right and left should be sloped off, to receive the bond of the adjoining work.

When the house the bricklayer is employed upon is intended to have other houses parallel with it, half bricks in a straight line with the front, should be left projecting from every alternate course, at the corner or corners to which the addition is intended to be made; or otherwise, an excavation equal to the breadth of a brick in front, and to the thickness of the wall from front to back, should be left in the alternate courses. In either case, the two fronts will be bonded together, and the gaps, so frequently deforming contiguous houses, when the fronts have been built independently of each other, will be prevented.

Bricks, as a building material, have several advantages over stone; from their porous texture, they unite better with the cement, are much lighter, and the walls built with them are very little subject to damps arising from the condensation of the moisture in the atmosphere. When all materials are ready, a good workman with his labourer will lay a thousand or twelve hundred bricks in one day.

Brickwork is measured by the square foot, reduced to the thickness of one brick and a half; thus a wall two bricks thick, ten feet long, and three feet high, and therefore containing only thirty square feet of surface in front, would be called forty feet reduced. It is valued by the rod of two hundred and seventy-two feet. Facing and gauged arches are measured by the superficial square foot; and cornices by the foot running, or length.

V. MASONRY.—Masonry is the term used to designate the art of building with stone, as well as the work itself when executed.

All calcareous stones used in masonry, namely, those that burn to lime, if hard, of a close texture, and beautiful appearance, from the variegation, or clearness and uniformity of the colours, are called marble. The names of the different kinds of marble are generally derived either from their colour, or the place where they are obtained. The most valuable kind of milk-white marble is obtained in Italy, and is too costly to be often used for any but the smaller ornamental parts of buildings. This, when cut into thin slices, is semi-transparent. Many parts of the united kingdom abound with marble, which is mostly more or less coloured, often close in its texture, and capable of receiving a high polish. Derbyshire and Westmoreland, in England, are the counties which supply the greatest quantity and variety of marbles, some specimens of which are highly esteemed.

When marble that has been faced with a chisel, is intended to be polished, it is ground by rubbing it with rough-grained freestone, assisted by sand and water, until the chisel marks are removed. Finer and fine-grained freestone, with water, but no sand, is then used, till the surface becomes very smooth. If the finer grit-stones be found too slow in their operation, a little fine flour of emery is used. The last and highest lustre is given with oxide of tin, well known under the name of putty. When the surface of the marble to be polished has been cut with a saw, the very rough freestone and sand are not necessary. In other respects it must be finished by the same process.

Limestone is a coarse kind of marble, and is cut and polished in a similar manner. In many districts, it forms immense strata. From its great hardness, it is only hammer-dressed when used for the fronts of buildings; but when this is done in the best manner, the effect is very fine.

The stone most commonly used in London, is Portland stone, which is brought from the island of Portland in Dorsetshire. It is of a dull whitish colour, though the buildings constructed with it have a handsome appearance. When recently dug, it is soft, and easy to work, but acquires hardness with age. Although it contains silex, the hardness it acquires is not so great that it will strike fire with steel. Under great pressure, Portland stone is apt to splinter at the joints.

Purbeck stone is brought from the island of Purbeck, also in Dorsetshire; it is mostly employed in rough work, such as steps, paving, &c.

Freestone is a general name for stones of very different qualities as to their value in building. It consists of clay and silex, sometimes the silex amounts to nearly one-half its weight, but generally it is considerably less, and the hardness of the stone varies with the proportions of its component parts. It is often called grit or sand stone. It is a very plentiful stone; the strata of entire districts, under a slight covering of soil, appearing, in various instances, to be composed of it. The particles of some kinds of it have so little cohesion, that small bits may be granulated between the fingers; this is the sort commonly used for filtering stones. All kinds of it are softer when taken out of the quarry, than they afterwards become when dry, or after long exposure to the atmosphere. Freestone is generally about two and a half times the weight of water. That from Hollington, near Utoxeter, is of a whitish or yellowish gray; that from Knipersly, in Staffordshire, is of a bluish gray, and so infusible as to be used as a fire stone. The colour of freestone is often a dull red, but sometimes so nearly white, that buildings constructed with it look as well as those of Portland stone. Different parcels of freestone, taken from the same quarry, frequently exhibit a considerable diversity of colour; a circumstance which gives a motley appearance to buildings in other respects perhaps faultless. When the stone has been recently dug, and is damp, these differences are often not perceptible. If, therefore, uniformity of appearance be desired, the stones should be faced, dried, and sorted before they are used. Freestone is incapable of receiving a polish, and therefore, when it has been cut with a saw, it is rarely submitted to any subsequent operation to produce greater smoothness; but when it has been reduced with the chisel, it is made smooth with another piece of stone of the same kind, along with sand and water. When the freestone has a laminated texture, it is called flag-stone, and is divided into thin pieces for the purpose of covering houses, and for flooring.

The position which stones have had in the quarry, is not a matter of indifference to the attentive mason. Stones intended to sustain great vertical pressure, as pillars, should stand in a building as they stood in the quarry from which they were taken; for pillars, the axis of which were horizontal in the quarry, when placed perpendicularly, are apt to split under a great strain. Perhaps all stones, however solid they may appear, possess more or less of a laminated texture,—a property doubtless occasioned by separate depositions, or crystallizations of their peculiar matter. What kind of a pillar any stone well known to be laminated, would produce, in different positions, it is not difficult to conjecture. If, for example, a block of flag-stone were converted into a pillar, so as to leave each lamina or flag of which it is composed posited horizontally, it would sustain any weight not capable of crushing it to atoms; but if the lamina were placed in an inclined position, so as to form an acute angle with the axis, an inconsiderable pressure would occasion them, where the cohesion was slightest, to slide over each other; lastly, if the lamina were placed parallel to the axis, the pillar, under sufficient pressure, would divide vertically into several parts, and though rather stronger than in the last instance, would still be comparatively weak. An attention therefore to the position of stones, and to veins or other signs which may indicate the existence of lamina, well deserves the mason's regard.

VI. *Of Cements for Masonry.*—The cement used by the mason for the ordinary purposes of walling, is mortar, differing not from that used by the bricklayer; and as we have already treated of this subject rather at length, a few remarks in this place will suffice. For the joints of hewn stone, the mortar should be much finer than the bricklayer requires; and sometimes a mixture of oil-putty, or very thick white-lead paint, is used as the cement. These compositions will last longer than almost any stones, and will remain prominent when the face of the softer kinds of stone has been corroded by age.

The cement used in setting column stones, is mostly oil-putty, or white lead mixed with chalk-putty, or fine mortar. Sometimes columns are set upon milled lead; in this case, the lead should not be quite equal to the column in diameter, but so as to leave a narrow ring externally, which must be filled with oil-putty.

In situations not exposed to damp, plaster of Paris is employed as a bedding for stones or marble. When a mantle-piece is composed of valuable marble, the various pieces are commonly very thin. In this case, a considerable thickness of plaster of Paris is laid on the back, and a slate or some ordinary stone bedded in it, to give greater strength. Good plaster of Paris is scarcely to be met with, nor are the causes of its imperfections generally understood by workmen. We shall therefore point them out, and give directions for preparing it of a uniform and excellent quality, when we treat of casting ing in plaster.

The Greeks and Romans constructed their works of wrought stone without cement; but as they used a profusion of cramps and bands of iron and bronze, and the beds of the enormous stones they used were finished with almost mathematical precision, their edifices were substantial and durable in the highest degree. Metallic bands and cramps are still used in aquatic works, as well as for lofty steeples, and other slender buildings much exposed to the action of the winds, also to connect the different stones composing mantle-pieces, &c. with the wall.

VII. *Of Stone Walls.*—The propriety of erecting suspended or inverted arches, according to circumstances, and other general directions already given respecting foundations, being as applicable to stone walls as to those of brick, need not be adverted to again. The explanation of a few technical terms will therefore be our first object.

Stones which run through the thickness of a wall, in order to bind it, are called *bond stones*; in some parts of the country they obtain the name of *through stones*.

When the side or sides of a wall lean back, so that the plumb would fall within the base of the wall, the inclination is called *battering*; it is generally made about one inch in a foot.

The large stones at the base of a foundation, which project beyond the vertical surface or front of the superincumbent wall, are called *footings*.

The parts of a wall between apertures, or between an aperture and the corner, are called *piers*.

The *beds* of a stone are its upper and under surface, which are generally in a horizontal position within the wall..

Walls built with unhewn stone, with or without mortar, are called *rubble walls*. Rubble walls are of two kinds, the coursed and the uncoursed. In the coursed, the stones are hammer-dressed or axed, and adjusted by a sizing rule, so that each row of stones forms an horizontal surface. In the uncoursed, the stones are used in a rough state, nearly as they come out of the quarry.

Walls which are faced with squared stones, hewn or rubbed, and backed with rubble, stone, or brick, are called *ashlar*.

Wall-plates are horizontal pieces of timber, commonly laid even with the interior of walls, for the ends of the joists and other timbers to rest upon.

The footings of walls ought to consist of the largest stones which can be conveniently procured. It is better to have them of a rectangular form than any other, and if not square, their largest surfaces should be laid horizontally. With this shape and disposition, they will make the greatest resistance to sinking. If the stones intended to be employed as footings deviate materially from a rectangular figure, when received from the quarry, they ought to be hammer-dressed; as, if they taper downwards, or rest upon angular ridges, they will be apt to give way under the weight of the superstructure. When the footings can be obtained the full breadth of the wall in one piece, they are to be preferred; but when a sufficient number of stones of this description cannot be obtained, then every alternate stone in the course may be the whole breadth, with two stones next to it, disposed like two stretchers in a nine-inch wall of Flemish brick-work. When the largest stones which can be conveniently obtained, are insufficient even for the latter arrangement, the most suitable which can be procured, must be disposed so as to break in the best manner circumstances will admit, the vertical joints in the same course, as well as those of the different courses with respect to each other. Each course, also, should be well bedded in mortar.

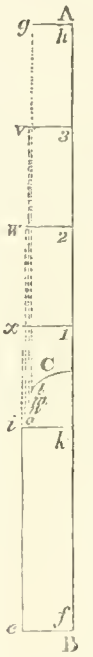
When bond timber will be required, the uncoursed rubble is an inconvenient mode of building, as the heights on which they are disposed must be levelled. The best kind, or coursed rubble, admits of bond timbers without difficulty, for though the different courses are not of the same height, the surface of each of them is level; but as the walls in which bond timbers are introduced, are apt to warp or even fall in case of fire, the use of them should be avoided in strong well-built walls.

The stones of an ashlar front should have their upper and under surface correctly parallel with each other, and correctly at right angles to the face. If these surfaces be carelessly left concave, they will be apt to splinter near the edge under great pressure. On the right and left they should taper inwards, but the taper should not be continued quite to the face, though it may reach the face within an inch or two. The ashlar stones having the form of a truncated wedge, they will in each course present a series of angular indentations within the wall, like the spaces between the teeth of a saw. The stones are so selected and disposed that the vertical or upright joints, and consequently the angular spaces, of one course fall on the middle of the stones below. By this means the ashlar face is bonded to the rubble, brick, or rough stone of the back, and the strength of the wall much greater than if each stone was of an equal rectangular figure. Strength is also to be promoted by adopting a plan not commonly regarded, that of sorting the stones, so that in each alternate course they will extend farther into the wall than those of the course immediately above and below. In ashlar work, the bond stones, which ought frequently to be introduced, cannot like the other stones have a wedge-like form; they must be rectangular; and they produce the best effect, when so disposed in each course that they will be opposite the middle of the space between the two bond stones in the course immediately above and beneath them.

VIII. *Of Stone Columns.*—When large stone columns are made in one piece, their effect, from that circumstance alone, is very striking; but as this advantage is not always obtainable, the next object is to make the joints as few and as minute as possible, as well as to be very attentive in selecting the different stones to be combined, that the joints may not be described at a distance, by the commencement of a different colour. From what has been said in the section on the different kinds of stone, it will be understood that none but horizontal joints can be allowed in any shaft; all others being inconsistent with the laws of strength.

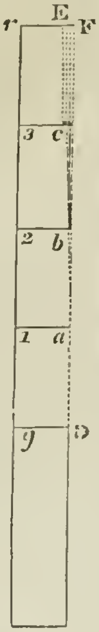
The stones proper for an intended column being procured, and the order in which they are to succeed each other being determined, the next consideration will be to ascertain the exact diameter proper for each end of every one of them. For this purpose, draw an elevation of the proposed column to the full size, divide it by lines parallel to the base, into as many heights as the column is intended to contain stones, taking care that none of the heights exceed the length that the stones will produce. The working of the stones to the diameters thus obtained then becomes easy. The ends of each stone must first be wrought so as to form exactly true and parallel planes. The two beds of a stone being thus formed, find their centres and describe a circle on each of them. Divide these circles into the same number of equal parts, which may for example amount to six or eight. Draw lines across each end of the stone, so that they will pass through the centre and through the opposite divisions of the same end. The extremities of these lines are to regulate the progress of the chisel along the surface of the stone, and therefore when those of one end have been drawn, those of the other must be made in the same plane, or opposite to them respectively. The cylindrical part of the stones must be wrought with the assistance of a straight-edge; but for the swell of the column, a diminishing rule, that is, one made concave to the line of the column, must be employed. This diminishing rule will serve to plumb the stones in setting them. If it be made the whole length of the column, the heights into which the elevation of the column is divided, should be marked upon it, so that it may be applied to give each stone its proper curvature. But as the use of a long diminishing rule, when the stones are in many and short lengths, would be inconvenient, rules corresponding in length to that of the different heights may be employed with advantage.

Of the different methods which may be practised, to obtain the curvature of the rule to be used in the diminution of the shaft of a column, the following may be considered the easiest and best adapted for general use: Let A B, in the annexed figure, represent the height of the column, *e f* the semi-diameter of the lower part, and *g h* the semi-diameter of the upper part, according to the customary proportion of the diminution. As the lower one-third of the column must be cylindrical, draw a line from *e* to *i*, parallel to A B. What we now want is, to obtain a curved line from *i*, which will fall into *g* without making the diameter of the upper two-thirds of the column in any point greater than that of the lower or cylindrical third. With the radius *i k*, draw the quarter of a circle C. Draw a line from the narrowest part of the column, that is, from *g*, parallel to the axis or middle line A B, till it cuts the quadrant of a circle C. Divide the arc contained between *i* and the point where *g* cuts C, into four equal parts, as *l*, *m*, *n*, *o*, and divide the height A *k* into the same number of divisions as this arc, as 1, 2, 3. From the point *m* draw a line parallel to the axis, which will cut the transverse line 3 at *v*; from *n* draw another line parallel to the axis, which will cut the transverse line 2 in *w*; in the same manner draw a line from *o* to the transverse line *l*, which it will cut in *x*. Now the curved line of the column, between *i* and *g*, must pass through the points *x*, *w*, *v*; therefore at or near all the points from *i* to *g* inclusive, drive in two pins or nails, in such a manner that the direction in which each pair of nails stand shall be the same as the transverse lines of the column. Between each pair of nails, also, there must be just sufficient space left to admit a thin slip of wood, like a lath, or some other equally flexible substance, and care must be taken to fix the nails in such a position, that when this slip of wood is placed between them, either its inner or its outer perpendicular surface shall exactly coincide with the several points of diminution *i*, *x*, *w*, *v*, *g*. This being done, it is easy, with a pencil or any marking instrument suited to the surface worked upon, to draw a line along the slip of wood, which line will be the curve of the shaft. The piece intended to be used as a diminishing rule may have the curve made on it, or transferred to it, as may be deemed most convenient. It will also be understood, that the number of the parts into which the arc *l i*, and the height A *k* are divided, and which determine the number of diminishing points obtained, may be varied at pleasure. In no case, however, can it be considered advisable to make these divisions fewer than four, though for lofty columns they may be made two or three times that number, as they constitute so many checks upon the irregular or imperfect flexibility of the lath or spring rule. As so much of the beauty of a shaft depends upon the easy and imperceptible transition from the cylindrical to the tapering part, it may be advantageous to divide the arc from *i* to *o* into two parts, and the division *k* 1,

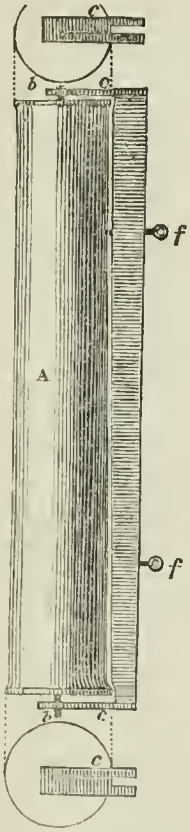


of the shaft, also into two parts; a diminishing point will then be obtained between i and x, which will be of use to lessen the possibility of imperfection.

Another mode, which we shall recite, of diminishing a shaft, is not essentially different from the preceding: Divide the shaft from D to E, in the first figure, into four parts, as 1, 2, 3; divide the space E F, which is the difference between the superior semi-diameter E r, and the inferior or lower diameter D q, into the like number of parts, *viz.* four. Draw lines from each division on E F tending to the point D. The first line next to F will reach to D, the point from which the diminution commences, in a direction parallel to the axis; the next line, reckoning from the same side, will give the point *a*; the third line the point *b*; and the fourth line the point *c*; a line from the point E, which is the limit of the diminution, need not be drawn. The points E, *c*, *b*, *a*, D, constitute the places where the nails must be driven in, to direct the path of the lath as in the last example. Some artists prefer this mode of diminution. Here, also, as before, the number of the divisions is optional, but a greater error may be committed by making them too few than too numerous.



To draw the flutes and fillets on the shaft of a column, the following will be found an easy and effectual method: Let A, in the second figure, be the shaft; make a hole exactly in the centre of both ends, and into each hole drive a piece of wood, so as to be quite tight, and to project five or six inches. The projecting parts *b b*, of the pieces of wood, must be well rounded off, and made exactly in the middle of the ends. Being provided with a diminishing rule, made as above-mentioned to the curve of the shaft, it may here be used as the ruler, by fixing it in a groove in two pieces of wood, c c, so as to revolve with them upon the pins *b b*. The edge of the rule must be brought very near the shaft, and one side of it must tend exactly to the centre, which is done by giving that direction to one side of the grooves in c c, as shewn by the dotted lines *a a*. As the diminishing rule *d* is commonly made rather slender, and therefore will be apt to bend with the force employed to draw the lines, it will be proper to fix a piece of wood, of sufficient thickness to keep it straight, on the back, or that side of it which does not tend to the centre. As, in marking a long column, there may be some difficulty in keeping the rule steady while the lines are drawn, the strong piece of wood thus attached to the back of the diminishing rule may have one, two, or more screws, according to its length, passing through it, as *f f*, and pressing against the shaft, by which means the rule will be staid at any part of a revolution, much more effectually than with the assistance of several men. The screws ought to be of wood, or, if iron, their extremities should be prevented from injuring the stone, by the interposition of a flat piece of metal, or some other suitable substance. These arrangements being made, the lines desired may be drawn with any sharply-pointed steel instrument kept close to the rule, with the greatest ease and precision, from divisions previously marked at one end. To obtain these divisions, suppose it were desired to flute the Ionic, the Corinthian, or Composite columns, the circumference at one end will be divided into six equal parts, by taking half the diameter at that end, and applying it round the said circumference; and if each of these divisions be divided into four, the whole circumference will be divided into twenty-four. In order to make the proportion of a flute to a fillet as *one* to *three*, divide any one of these last divisions, or twenty-fourth part of the circumference, into four equal parts, and one of these parts will be the breadth of a fillet; which being set off from the same side of each division, the whole shaft will be properly divided for flutes and fillets, and consequently prepared for the use of the rule.



To draw the flutes and fillets on a diminished pilaster, make a line down the middle of the face of it, from top to bottom; divide this longitudinal line into any convenient number of equal parts, and through the points of division draw transverse lines crossing the breadth of the pilaster; set off the flutes and fillets on each transverse line; fix pins or nails at each corresponding point of the transverse line, and draw the lines with the help of a pliable slip of wood, as in obtaining the diminution of a shaft.

IX. *Stone-bridges* have been explained. *See* BRIDGES.

MISCELLANEOUS REMARKS RELATIVE TO BUILDING.

Under this title, we shall include a variety of particulars, either not belonging, or not exclusively belonging, to Masonry or Bricklaying. Under the first head of this subdivision of the chapter on Building, the earliest notice seems due to a sketch of the general rules proper to be observed with respect to the

X. *Situation and Plan of Houses.* *See* ARCHITECTURE.—With respect to situation, when the person who is intending to build enjoys the advantage of choice, the proximity of marshes, fens, of a boggy soil, or stagnant water, should be avoided. If a river be very near, the site of the house should be on elevated ground, so as to be out of the reach of the unwholesome fogs and mists arising from it early in the morning. A neighbourhood where cattle thrive, and where the inhabitants are healthy and cheerful, or are remarkable for their longevity, may be regarded as possessing a salubrious air. The most essential requisites of a good situation, or those which are most conducive to health, being obtained, minor advantages may be regarded according to their importance. Abundance of water, fuel, and ways of easy access to arrive at the house, are conveniences of lasting value. The advantages of a situation, with regard to prospect, are of a more problematical nature, as they are so differently valued by different persons. A man of taste will, however, undoubtedly prefer a spot, the prospect from which is most agreeably diversified in the distribution of its land, wood, and water; and those who have little or no relish for the charms of nature, will perhaps consult their own comfort more than they may be aware of, by making the same choice. There are very few so obstinately morose, as to be uninfluenced by the opinions of others; and to observe those about them, particularly visitors, warm in their admiration of the surrounding scenery, may create a beneficial complacency which they would otherwise want.

Trees at a little distance from a house are better than hills, as they yield during the day, in summer, a cooling, refreshing, sweet, healthy air; and, in winter, break and diminish the keenness of the winds. Hills on the east and south side are the most inconveniently situated. If the site of a house be low, the first floor should be set so much the higher. Cellars contribute to the dryness of a house, if the ceilings and floors be good.

With respect to the situation of the parts of a house, the studies, libraries, and chief rooms, particularly the bed-chambers, should face the east; those offices which require heat, as kitchens, brewhouses, bakehouses, and distilleries, should have southern aspects; and those which require a cool fresh air, as cellars, pantries, dairies, granaries, a northern one, which is also proper for galleries, paintings, museums, &c. which require a steady light.

When a situation has been fixed on, the plan and elevation of every part should be made by some person well acquainted with the theory and practice of building. A skilful architect will not only make the structure handsome and convenient, but will save the great expenses often incurred in rectifying the blunders of hasty and injudicious management. For a small building, the elevation of each front, with a plan, may indicate, with sufficient correctness, its ultimate advantages; but for a large mansion or structure of any description, consisting of many complex parts, the most certain way to prevent mistakes, is to have a perfect model of the whole made to a regular scale. In order that such a model may not mislead the judgment by pleasing the eye, it should be made of plain wood, of one colour.

Lodges and small houses, standing alone, have an agreeable appearance when of a cubical figure; but large mansions of this shape look rather clumsy; an oblong is therefore commonly preferred, care being taken not to make the plan so long as to lose much room in the passages which will be required, and which will be difficult to light. When the length of a mansion does not exceed the breadth more than one-third, the proportion is good.

XI. *Of Rooms.*—The principal objects to be regarded in the arrangement and proportions of rooms, are doubtless those of conveniency, and their adaptation to health. Rooms, the plan of which are rectangular, give the greatest facility to convenience of arrangement, without the disadvantage of losing the space rendered unavoidable by adopting circular or other curved forms; but with regard to health, the height of a room should at least be ten or twelve feet, and this point should be regarded even in apartments too small to render such an elevation proper in an architectural point of view. A square is an agreeable form, but is most proper for rooms not exceeding a moderate size, as it cannot well, if very large, be completely lighted from one wall, and the company, while ranged on each side, are too far apart. For spacious apartments, a rectangular parallelogram or oblong is a more convenient figure, and, with regard to beauty, every variation in the proportion, from nearly a square to a square and a half or sesquilateral, may be employed. If the length of the plan be extended materially beyond a sesquilateral, the apartment obtains rather the appearance of a passage or gallery, and it becomes impossible to adjust the height so as to suit both the length and breadth. In square rooms of the first story, the height may be from four-fifths to five-sixths of the breadth of the side; and in oblong rooms, the height may be equal to the width. An error in favour of height, is preferable to making a room too low.

The height of rooms on the second story may be one-twelfth part less than that of the chambers below: and if there is a third story, divide the height of the second into twelve equal parts, of which take nine for the height of such rooms.

An eligible length for galleries is five times their breadth, and they should rarely exceed eight times their width in length; their height may exceed their breadth in the proportion of a third or even three-fifths, according to their length.

As, however, in modern houses, all the rooms of the same story are commonly of the same height, and convenience requires them to be of different sizes, according to their use, it follows that the best proportion of the height to the other dimensions, cannot always be observed, without incurring some extraordinary expense. Where expense is not a hinderance, the height of the story may be suited to the principal rooms, and the middle-sized rooms may be reduced by covering the ceilings, with a flat in the middle, or by groins or domes, which will add to their beauty, independently of bettering their proportions.

Precautions should be taken to prevent the effluvia from the kitchen, brewhouse, and other offices, from penetrating to the bed-chambers and dining rooms. The most difficult object to attain of this description, is to prevent the effluvia of the kitchen from annoying the dining-room, to which the access from it should be as easy and short as circumstances will allow, for the convenience of the servants waiting at table. In country mansions, which admit of the greatest liberty of plan, and where the kitchens are above ground, this may generally be done by such an arrangement of the doors and passages of communication, that no current of air from the kitchen can proceed directly towards the dining-rooms. But in town houses, where the kitchen is beneath the parlour floor, and therefore not only far nearer in point of situation (though not perhaps of access for persons) than it is usually placed in the country, but on a lower level, the lighter warm air, charged with the smell of the various operations of cookery, is apt to be felt above, from its disposition to ascend. It may, however, be effectually removed by a small separate funnel, carried up in the stack with the rest, and next to that of the kitchen. This funnel, to be used for no other purpose, must have its throat or lower opening level with the ceiling of the kitchen. The lighter air, charged with the vapours of the cooking, will then pass off into the external atmosphere by this aperture, instead of accumulating under the ceiling of the kitchen, until it forms a stratum as low as the top of the kitchen door, and then ascending through the house by the stairs and passages. The opening of this funnel or pipe may be closed by a hinged door, when no operation is going on in the kitchen which can create a disagreeable smell.

Every chamber in a house should, if possible, have a fire-place, the place of which, in those employed as bed-rooms, if they are not very spacious, should be about two feet or two feet and a half out of the middle, to allow room for the bed. In apartments of twenty or twenty-four feet a side, this arrangement need not be studied, as the bed can without it be placed sufficiently far from the fire.

XII. *Chimneys.*—That no apartment can be comfortable which is incommoded with smoke, will not be contradicted; yet we find a very general disregard of the precautions which would secure a strong draft up the chimney. Masons and bricklayers follow their own fancy or judgment, which are often influenced by their convenience, or by local customs, with little regard to rational principle. It frequently happens that the smoking of chimneys is occasioned by their being carried up narrower at the top than below, or by their having one or more sharp angular turns. When chimneys are constructed in a pyramidal or tapering form, and are besides left rough or unplastered, with stones or bricks projecting into them, as well as the mortar pressed from the joints in the wall, their smoking is almost certain. The air, rarefied by the fire, passes up a chimney with the smoke; but as it recedes from the impelling power, or fire, it moves slower, and requires a greater portion of space to circulate through; if then, the upper part of a chimney, instead of being wider than below, be contracted, and if the roughness of the walls concur at the same time to increase the obstruction, it is no wonder that the smoke, taking the path of least resistance, should find its way into the room, whenever assisted by a current from above. It may be urged, that a chimney wider at the top than below, allows the wind more liberty to blow down; but it must be considered, that the wind having no adequate resistance from above to overcome, must necessarily return, and thus facilitate the free egress of the smoke. On the other hand, when a current of air rushes down a pyramidal chimney, it becomes confined or wedged in, and if urged by a constant wind, the rarefied air from the fire cannot make head against it, and therefore the smoke bursts into the room.

Experiments, in endless variety, and often at great expense, have been made to prevent or cure smoky chimneys; we shall notice some of the most simple and efficient; but it will be proper to explain, in the first place, some of the terms which are used in speaking of chimneys. The aperture from a chimney into the room, is called the *fire-place.* The projecting parts of the wall, on the right and left of the fire-place, are called *jambs.* The head of the fire-place resting upon the jambs, is called the *mantle.* The mantle, and the whole side of the chimney above it up to the top, are called the *breast.* The side of the chimney, called the breast, being pointed out, the application of the term *back*, to the opposite side, explains itself. The sides of the fire-place contained between the jambs and the back are called *covings.* The throat is that part of the opening immediately above the fire, and contained between the mantle and the back.

When chimneys are bounded on the top by a zigzag line, so as to resemble the teeth of a saw, they are found to be far less liable to smoke than those in other respects under the same circumstances; and in a great variety of cases, the cheap and easy expedient of altering the tops of smoky chimneys to this form, has been attended with complete success. The partitions in a stack should be indented as well as the outside wall.

The fire-place is generally an exact square. Its height, in large rooms, is often very properly made less than a square, and in small rooms, particularly when the chimney is in a corner, it is rather more. In rooms from twenty to twenty-four feet square, or of equal area, it may be from four feet to four feet and a half broad: in rooms from twenty-four to thirty feet square, it may be from four and a half to five feet; and in rooms still larger, it may be extended in a similar proportion to six feet. If much beyond six feet, whatever may be the size of the room, the effect will not be good; for if the fire be proportionate, it will excite rather the idea of a furnace. Two fire-places will certainly be better than one of such overgrown dimensions. As to the effect of the form of this aperture on the draft, its breadth is not very important, provided it be not so narrow as to prevent the covings from standing with their greatest power of reflection towards the room; but the height should seldom exceed two feet six inches to the under side of the mantle. The throat should not be more than four or five inches wide; but should be contracted by a part moveable at the back, when the chimney requires sweeping. The nearer the throat is brought to the fire, the stronger the draft will be. For fire-places about three and a half feet wide in front, the flues of chimneys, above the throat, are usually made equal to about twelve inches square; and the general rule is, to make the area of the horizontal section of the flue equal to the area of the horizontal section of the fire. If the flue were smooth and circular, this mode of proportioning its size would doubtless be found to allow it unnecessarily large. Where bends are required in a flue, they should be in a curved, and not an angular direction. High chimneys always draw better than low ones, as, in proportion to their length, the influence of the wind extends a shorter way down them. An apartment made wind-tight, by listing the doors and other contrivances, is liable to be incommoded with smoke, from the want of draft, even when the chimney is constructed in the most proper manner: a few minute holes, communicating with the exterior, will, in such cases, constitute an effectual remedy.

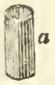
Another method of increasing the draft of a chimney, consists in setting the grate, if a Bath stove, eleven or twelve inches from the fender; and in cutting away the back of the chimney, so as to leave a space of two inches between it and the back of the grate. If the grate be of the common form, the sides should be filled up with brick work. By this construction, the air that passes behind the back of the grate, assisting to impel the smoke, prevents its bursting into the room. —That a chimney clogged with soot will be apt to smoke, is so well known, as to require no notice here.

The evils attending the practice of cleaning chimneys by means of climbing boys, are of the first magnitude. The degraded situation of the children in this employment, so destructive to health at any period of life, but especially in early youth, has often and strongly excited the commiseration of philanthropical men, and many schemes have been proposed to render their ascending unnecessary, and thus abolish a practice so offensive to humanity. Of these plans, the most feasible consists in the use of brushes, which are drawn up and down by men at the top and others at the bottom, or are pushed up from the bottom, and drawn down by persons within the apartment. The former method is inconvenient and expensive; the latter, which is the invention of Smart, is often practised, and has justly received much approbation. The rods by which the brush is pushed upwards, are made hollow and in short lengths, and are connected together by a cord passing through them. As soon as the lower end of the first rod is pushed about the height of the mantle, another rod is slipped over the cord, and the lengthening of the whole is thus continued, till the brush clears the top of the chimney, where it spreads itself out, and is prevented from contracting by a spring; so that the soot is brought down along with it. But as long as the practice is continued, of making chimneys square, crooked, and rough, it is to be feared that no sweeping apparatus can be contrived which will be found completely successful. Inventions recommended solely by their humanity, are often so slow in their progress towards general adoption, that an eminent service will be rendered to society, by the man who makes the convenience and interest of individuals conspire with their benevolence, to promote the purpose before us.

Amongst the various improvements of modern times, perhaps few have been more really beneficial than the use of metals, for purposes to which, only half a century back, they were hardly thought applicable. It is perhaps not generally known that the great variety of articles of fittings now constantly kept in ironmongers' shops, in the remotest villages, were hardly known in country places at the beginning of the last century; but wherever a house was built, its bolts and latches were mostly of wood; its windows, if sashes, were massive, and if one sash ran, the sash-cord ran over a wooden pulley; and many other minute fittings were either of wood, or, if of metal, were individually made by the adjacent smith, who produced a clumsy article at a great waste of time and labour. We now see the use of iron and brass extensively superseding timber and stone in the most advantageous manner. At Eaton Hall, the magnificent mansion of Lord Grosvenor, near Chester, the tracery of the windows, many shields, a stair-case, and a variety of ornaments, are of cast iron. A large portion of tracery pannelling, for a terrace balustrade, are of the same material, and being painted and sanded, have all the beauty of stone. Hollow Grecian balustrades, for a public building in Ireland, have been made of iron, in Liverpool. Two patents have been taken out for roof framings of iron, one of which, at least that of J. Cragg, Liverpool, is particularly remarkable for its simplicity, and the beauty of its execution. This gentleman also executes stair-cases of iron, in so accurate a manner, that they may be put up at any place in a few hours. Cast iron bridges have long been deservedly celebrated, and the dearness of wood, and the supposed inefficiency of the patent stone pipe, have caused cast iron water-pipes to be used in London, and many other places. Cast iron has also been advantageously used for beams and their supports in a large way, the Trustees of the Duke of Bridgewater's canal having used it for beams in a new warehouse at Liverpool, of more than thirty feet clear span; and the Carron Company have used some excellently arranged hollow iron stanchions in a new warehouse at Liverpool. Rennie employed it abundantly in the warehouse of the London docks; and its use in aqueducts and bridges is now proverbial.

There is yet another purpose, for which iron seems so well adapted, that it deserves at least a fair trial; it is that of cast pipe for chimneys. The present mode of building chimneys is not only extremely unsafe, but also takes up a great deal of room; and from their being square, there is a great difficulty in cleaning them thoroughly, except by climbing boys, or, as is frequently practised, by purposely firing them. Smart's apparatus does not completely answer, because the corners which contain most soot do not get swept completely, and are often not touched. Another objection to ordinary brick square chimneys is their smoking, or, in other words, not drawing; an evil not considered, by those who suffer from it, of the most trivial magnitude. All these inconveniences might be remedied by using for chimneys cast iron pipes three-eighths of an inch thick, and when once the utility of the plan became known, the article would become as common in iron shops as fronts of grates. The present openings into the room are built far too large, and are now generally contracted by various means when the grate is set, but while the present arrangement of brick chimneys for climbing boys remains, they cannot well be much altered; but if iron pipe were used, an iron fire-place top would be cast for the pipe to fit into, and would of course be made of various sizes and shapes like grate fronts, and iron articles in general, cast by the Carron Company and other founderies.

More clearly to exemplify the advantages of this invention, it will be proper to detail the arrangements necessary. Prejudice will at first perhaps require the pipe to be eight inches in diameter, though there is little doubt that seven, six, or even five inches diameter would be amply sufficient for the largest fire. However this may be, it should be cast in lengths of from three to five feet, which, at three-eighths of an inch thick, would render the pieces of a manageable weight; they should be carried up as close as possible to each other, and as four inches of brick-work is more than enough on each side of them, in walls of two bricks thick, they would cause no projection into the apartment. The interstices between

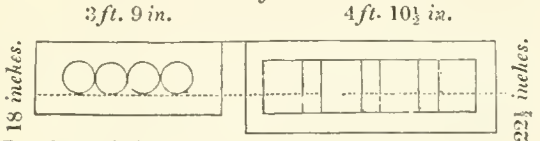


the bricks and pipe should be filled with earth, or, what would be still better rubbish and liquid cement. A bevel joint, *a*, in the figure, might be made to the pipe, to fit so closely that no crevice would be left to lodge soot, when the cement surrounded the exterior.

If one, or indeed all the chimneys in a stack, constructed upon this plan, were to get on fire, it would be of little consequence, as the heat could never be so great as to act through the pipe and such a solid mass as the stack would be. The soot would not lodge in such chimneys as in the common ones, for in a round chimney the draft would clear more smoke out of the chimney before it was condensed; and when they required cleaning, Smart's apparatus would sweep them completely.—When a house with ordinary chimneys is burnt, the stack usually falls down, tearing the walls, and rendering it necessary to rebuild them; but if a house with an iron-pipe stack was burned, it would not only in all probability stand, but act as a buttress to sustain the walls: or, in case it fell, the greater part of the pipe would remain as fit for use as at first. Although it may be least trouble generally to leave the breadth of half a brick round the pipe, yet, in small buildings, and in cases where room is wanted, a flat brick would, there is no doubt, be quite sufficient for all purposes of safety. In all cases, too, where iron pipe may be used, the labour of plastering chimneys will be saved, which, though in many places omitted, is done to all well-built houses.

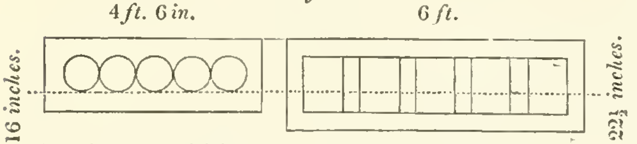
The saving of room which would be produced by the use of iron-pipe, in a stack of four eight-inch chimneys, will be immediately seen by the inspection of fig. 1; and fig. 2 exemplifies the same thing with respect to a stack with five chimneys.

Fig. 1.



Projection into the Room, four and a half in. if one and a half brick wall. *Projection into the Room, nine inches, if one and a half brick wall.*

Fig. 2.



Projection four and a half inches, if one and a half brick wall. *Projection nine and a half inches, if one and a half brick wall.*

If nine inches be allowed for the exterior diameter of the pipe, (and such an allowance will be enough for all contingencies,) it may be carried up, in all walls exceeding two bricks thick, without any projection into the apartments. In the corners of a two brick, or even a one and a half brick wall, there is sufficient room to carry up such a chimney, which would rather increase than diminish the strength of the wall, since nearly one-half of the space taken up by chimneys in the common way will be saved, under circumstances the most unfavourable to shewing the advantages of the new plan; for the diameter of the pipes is reckoned at the largest that can be required; and the brickwork surrounding the square chimneys, at the thinnest it can with any propriety be made.

The expense of round work, either in brick or stone, is probably the principal reason that round chimneys are not in general use, though the advantages of them, particularly in being free from the currents or eddies of air occasioned by square chimneys, are not unknown to intelligent builders.

Oval flues might be recommended as perhaps superior to the circular ones; for there are many situations in which they might be carried up advantageously with the conjugate diameter of the ellipse running parallel with the gable of the house, or the reverse.

Iron pipe, it is well known, answers perfectly well for stoves, and the portable furnaces of chemists, although the area of it is seldom more than half that of the fire, and the quantity of air required to maintain the vehement heat which can be excited at pleasure, occasions a much greater draft than that of ordinary domestic fires of twice the size. Hence the above plan only proposes to extend the use of a kind of chimney, the adequateness of which is already proved.

XIII. *Doors.*—The ancients, according to Vitruvius, frequently made their doors rather narrower in breadth at the top than at the bottom. These trapezoidal doors were probably adopted from their having the property of closing themselves, and in modern times they are useful besides as the simplest mode of raising the door, in the act of opening, above the floor, in order to keep it clear of the carpet. There are examples of them in the Bank of England; but they are not often introduced by architects.

Doors are varied in their dimensions according to the height of the story and the magnitude of the building in which they are placed. In private houses, they can rarely with propriety be made wider than four feet, and in general three feet will be sufficient. For small doors, when the height is to the breadth in the ratio of seven to three, the proportion may be considered good; but the height of large doors need not be more than double their breadth. The entrance doors of palaces and the mansions of noblemen, where much company resort, are often made from four to six feet wide; and those of public edifices may be from six to ten feet wide. Doors much exceeding three feet in width, should have folding leaves. In modern houses, it is not uncommon to have large folding doors, the opening of which serves, instead of removing a whole partition, to throw two rooms into one. In such cases, the width of the aperture will generally be of less height than twice its breadth, as all the doors of the same story are commonly of the same height.

When the principal door of entrance is in the middle, its communication with every part of the building is not only the most readily effected, but it contributes so much to the symmetry of the front, that when the plan renders such a position inadmissible, a blank door is frequently substituted for a real one, which is then made in the most convenient place. The entrance doors of stately houses are frequently adorned with porticoes, in the Grecian or Roman taste; but the most common mode of adorning entrance doors, is to surround them with an architrave, surmounted with a cornice, or with a frieze and cornice forming a complete entablature. These decorations are made of stone, wherever a suitable kind can be had at a reasonable price.

XIV. *Windows.*—In determining the number and size of windows, regard must be paid to the destination, local position, and elevation of the building, as well as to the cubature and height of the story in the rooms to be lighted, and the thickness of the walls. With respect to private houses, though considerable latitude may be allowed in the determination of this subject, still there are limits which cannot be disregarded without losing the beauty of proportion, and the convenience of a due quantity of light. In general, the piers should not be of less breadth than the apertures, nor more than twice such breadth. The windows, in all the stories of the same aspect, should be of the same breadth, unless a variation be required from this rule for the convenience of particular offices in the lowest story. The laws of symmetry and strength alike require them to be exactly one above another; this practice, so strangely neglected by our ancestors, is now, indeed, duly attended to. The apertures of windows should widen inwards on each side, by which means the quantity of light admitted will be nearly as much as if they were externally of the same size as the increased internal dimensions.

To determine the aggregate area of the windows proper to be made in an apartment, extract the square root of the cubature of such apartment, and the quotient will be the answer. For example, suppose the room to be forty feet long, thirty feet broad, and sixteen feet high, then $40 \times 30 \times 16 = 19200$, which product is, in feet, the cubature sought, and the square root of it, neglecting a small remainder, is one hundred and thirty-eight feet for the aggregate area of the apertures. One hundred and thirty-eight feet will make four windows of a handsome size and shape, adapted to the apartment in question; and if divided accordingly into four parts, thirty-four feet and a half will be the area of one of them. The area thus obtained, when set out for a ground floor, according to the customary rule, which allows rather more than two squares in height, each window may be about eight feet eight inches high, by four feet broad. By the same rule, the dimensions of the apertures of windows for rooms of any other cubature may be determined.

The sills of windows have been mostly made from three feet to three feet six inches distant from the level of the floor, as at that height they formed a convenient parapet to lean upon; but the French fashion having been introduced, of having the windows, at least in the principal drawing-rooms, down to the floor, window-sills are now, partly in imitation of it, made lower than formerly, and in ordinary dwellings are frequently not higher than two feet, and in the extreme not more than two feet six inches.

It will be proper to remind those who are partial to spacious and numerous windows, and who are not disposed to modify their choice by motives of economy, that as the aggregate area of the windows is enlarged, it becomes increasingly difficult in winter to keep apartments warm, the heat produced in them being so very speedily communicated through the glass to the atmosphere without. It is for this reason, that in Russia they often make their windows double, and as air is a bad conductor of heat, the stratum of it interposed between the two windows in the same frame, tends very materially to prevent the temperature of the room from being carried off. The cold season is not so severe, or of such long continuance, as to have occasioned the introduction of this practice for front windows into the United Kingdom, but it might be advantageously acted upon with respect to the skylights employed to light staircases, as such windows, when only single, contribute greatly to the speedy dissipation of the warm air which ascends to the top of the house.

The number of windows on each side of the entrance door should be equal, and an odd number of windows in an apartment, when they are all on one side of it, is better than an even number, as it avoids the necessity of having a pier opposite the middle of the floor.

The windows of the principal floor are generally the most enriched. The simplest mode of adorning them is, to surround them with an architrave, which sometimes has, and sometimes is left without, a frieze and cornice; frequently the whole of the windows are left plain, except the central one of the second story. When the windows of the principal story have pediments, those of the story immediately above should have architraves surmounted by a frieze and cornice, and those of a next higher story, an architrave only. The sills of all the windows in the same floor should be on the same level.

XV. *Stairs. See* Handrails.—To unite the requisites which a good staircase requires, namely, convenience in situation and form, with a sufficiency of light, affords one of the strongest proofs of an architect's skill. In stately mansions, the steps should not be less than four, nor more than six inches high; nor more than eighteen or less than twelve inches broad; and the width should not be less than six or exceed fifteen feet. In ordinary houses, the steps are generally made higher, and are almost necessarily narrower, both in width and length; but, while any thing like handsomeness of appearance and convenience of ascent are studied, they should not exceed seven inches in height, nor be less than ten inches broad, and three feet long. Stairs are ascended with more ease when laid somewhat sloping, or a little higher at the back. The ancients were partial to an odd number of steps; one consequence of which choice was, that the same foot which was placed on the first step was first placed at the top on the landing.

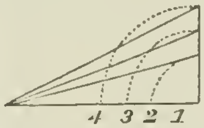
XVI. *Roofs.*—Architects include, under the term roof, not only the exterior covering of a house, but all the beams and other parts necessary to support that covering.

Among the ancients, in those countries where it seldom rained, roofs were made quite flat; but the Greeks, perceiving the inconvenience of this form, deviated from it a little, by inclining their roofs, as appears from several ancient remains, about one-eighth or one-ninth part of the span. The Romans, who had rather more occasion than the Greeks to provide for the speedy discharge of rain from their houses, made the height of the inclination of their roofs from one-fifth to two-ninths of the span. Among the northern nations of Europe, after the decline of the Roman empire, high-pitched roofs began to be in general request, and that was considered the standard form, the vertical section of which was an equilateral triangle. No part of the art of building has been more subject to caprice, than the height of the inclination, or, as it is usually expressed, the pitch of roofs. In the present day, a great variety of pitch is employed, but the equilateral one is seldom seen. In ordinary dwellings, the pitch of the roof is from one-third to one-fourth part of the span; but mansions and public edifices are still executed in every diversity of style that fancy or particular views can dictate.

High-pitched roofs discharge rain and snow more quickly than others; they are also not so easily stripped by the wind; the rain is not so easily blown between the slates, and from their approach towards perpendicularity of pressure, they are not so great a burden to the walls. They are, however, more expensive than low roofs, as they require longer and stronger timbers; and from their greater surface, they require a larger quantity of the covering material: but though low roofs have the advantage in point of cheapness, they require large slates, and great care of execution.

The roof is one of the principal ties of a building, when skilfully executed, in connecting the exterior walls. Some idea may be formed of the success with which scientific knowledge and experience may be employed in the construction of roofs, when it is observed, that roofs have been constructed sixty feet wide, although they have not contained a single piece of timber more than ten feet long and four inches square.

In determining the pitch of rafters, when mere fancy is not to be our guide, the nature of the intended covering should be taken into consideration, and the inclination proportioned accordingly. The following rules may be observed with prorpiety:—



For *Lead.*—Divide the width first into two parts, as in the annexed figure, and one of these parts into four, as 1, 2, 3, 4; with two of these parts describe a quarter circle, 2, which gives a proper pitch or slope to be covered with lead, and is called a pediment pitch.

For *Pantiles.*—Divide the width as before into two parts, and one of these two parts into four, as 1, 2, 3, 4; with three parts, describe a quarter circle, 3, which gives a proper pitch for use.

For *Plain Tiles.*—Divide the width into two parts; with one of them make a quarter circle, which gives a pitch or slope proper for the roof. The lighter the covering material, the lower the roof may be, and therefore the pitch for slates may be the same as that for the covering which the particular quality used most nearly approaches to in weight.

Tiles, though extensively used in many parts of the country, constitute a very heavy covering for houses, and, what is still worse, they injure the timber upon which they are laid, and tend to make a house damp, from the facility with which they are penetrated with moisture. The following experiment, by the bishop of Llandaff, decisively proves their great porosity, and their inferiority to slate. The Bishop observes, that sort of slate, other circumstances being the same, is esteemed the best, which imbibes the least water; for the imbibed water not only increases the weight of the covering, but in frosty weather, being converted into ice, it swells and shivers the slate. This effect of frost is very sensible in tiled houses, but is scarcely felt in those which are slated; for good slate imbibes but little water; and when tiles are well glazed, they are rendered in some measure, with respect to this point, similar to slate. He took a piece of Westmoreland slate, and a piece of common tile, and weighed each of them carefully; the surface of each was about thirty square inches. Both the pieces were immersed in water for about ten minutes, and then taken out and weighed as soon as they had ceased to drip. The tile had imbibed above a seventh part of its weight of water; and the slate had not imbibed above a two-hundredth part of its weight; indeed, the wetting of the slate was merely superficial. He placed both the wet pieces before the fire; in a quarter of an hour the slate was become quite dry, and of the same weight it had before it was put into the water; but the tile had lost only about twelve grains of the water it had imbibed, which was, as nearly as could be expected, the very same quantity that had been spread over its surface; for it was the quantity which had been imbibed by the slate, the surface of which was equal to that of the tile. The tile was left to dry in a room heated to sixty degrees, and it did not lose all the water it had imbibed in less than six days. If, then, tiles imbibe a seventh part of their weight of water in ten minutes, and cannot be deprived of this water without a degree of heat equal to sixty degrees continued for six days, it must be obvious that a roof covered with them, can, in this country, seldom be dry. The timbers also of the roof must be calculated to support their weight in their wet state.

The finest sort of blue slate, which is obtained in the neighbourhood of Kendal, is sold there for 3s. 6d. per load, which comes to £1. 15s. per ton, the load weighing two hundred weight. The coarsest sort may be had for 2s. 4d. per load, or £1. 3s. 4d. per ton. Thirteen loads of the finest sort will cover forty-two square yards of roof, and eighteen loads of the coarsest sort will cover the same extent. Hence there is half a ton less weight upon forty-two square yards of roof when the finest slate is used, than when it is covered with the coarsest kind, and the difference in the expense of the material is only 3s. 6d.; yet as fine slate owes its lightness, not so much to a difference in the quality of the stone from which it is split, as to the thinness to which it is reduced, it is inferior to the heavier kind in point of durability.

The following statement shews the average weight of the covering laid upon forty-two square yards of building, according to the material employed —

Copper	4 *cwt.*	Coarse slate	36 *cwt.*
Fine slate	26	Tiles	54
Lead	27		

Such are the advantages of slate as a covering, that wherever it can be procured without much land carriage, it obtains the preference of all other materials. Its durability is so great, that it has been known to continue sound and good for centuries; but all kinds of it are not equally excellent in this respect. Its most usual colours are white, brown, and blue, and the colour affords some index to the quality of the slate. The light blue sort is always the least penetrable to water, which the deep black blue is apt to imbibe rather freely. Several methods may be practised to ascertain the goodness of slate, when not brought from a quarry of well-known character. If a slate, when struck sharply against a large stone, produce a complete sound, it is a mark of goodness; and if it does not shatter before the edge of the zax, or instrument used for hewing it, the criterion is decisive. Another method is, to place the slate lengthwise and perpendicularly in a tub of water, about half a foot deep, care being taken that the unimmersed part of the slate be not in any way accidentally wetted. Let it remain in this state twenty-four hours: at the end of that time, if the slate be good, it will not have drawn water more than half an inch above the surface of that fluid, and that perhaps at the edges only, where the texture has been a little loosened in the hewing; but a spongy defective stone will draw water to the very top. Another mode of trial, on the result of which full reliance may be placed, is to weigh two or three of the most suspected slates, and note their precise weight: then immerse them entirely in water for twelve hours: take them out, wipe them as clean as possible with a linen cloth, and if their weight differs not, or differs but very little from what it was at first, they may be considered good; a drachm in a dozen pounds is allowable, but not more. The principal reason of the inferiority of the slates which imbibe much moisture, being that they are shivered by frost; when none but a porous kind can be easily obtained, they might doubtless be improved by the application of tar, as already mentioned for tiles, when treating of the manufacture of the latter article.

Among the artificial methods that have been invented for covering houses, a composition called tessera was a few years since in high repute. It consisted of tar, calcareous stone reduced to dust, and a little powder of burnt bones. These ingredients, duly mixed, were spread into sheets made equally thick, about four feet long and two feet wide, by passing under rollers; and when laid on the boarding of the roof, which might be either flat or angular, the sheets were cemented by a solder of the same materials.

When this composition first gained public attention, it was thought to be of incalculable value. It was said to be lighter than lead, to be considerably cheaper, to equal it in point of durability, and though apparently combustible, to be capable of resisting the effects of heat about twice as long as lead.

To secure the advantages of this important discovery, a patent was taken out by the inventor, December 22d, 1806, and agents were appointed throughout various parts of the kingdom. The confidence of builders was soon gained, and many houses were covered with this promising compound.

Experiment, however, which is the best test of excellence, soon detected the fallacy of theory, and those who had purchased tessera speedily found that they had laid out their money in buying a stock of repentance. It was shortly perceived, that it could not withstand the corroding influence of the seasons, that it would alternately swell and crack according to the temperature of the weather, and thus readily admit the rain, which it was expected to exclude. Having thus lost its character, it soon fell into disuse. Many houses that had been covered with it, were forced to be stripped, and to receive the old but partially discarded materials; and tessera having lived its day, is now known only in name.

XVII. *Floors.*—Flooring boards are mostly made of fir. The first class are selected free from knots, shakes, sap-wood, or cross-grained stuff: the second class consists of boards also free from shakes and sap-wood, but not from small sound knots; the third class contains the residue of any parcel, or such boards as cannot be included in either of the preceding classes. When an agreement is entered into for the erection of a building, the quality of the boards should be specified, to prevent subsequent disputes. As all boards shrink in the course of time, and as the quantity of their contraction increases with their dimensions, floors which are laid with very broad boards soon exhibit, at the joints, wide fissures that have an unpleasant appearance. It is therefore the practice in good houses, not only to select the best part of the wood, but to cut the boards into narrow scantlings; so that, if properly seasoned, and laid close at first, their shrinking afterwards is so small as to make no openings of consequence. Boards about five inches broad may be reckoned narrow, but when they measure nine inches or more in the same direction, they must be considered broad.

The manner of jointing flooring boards, and fastening them down upon the joists, is performed in a variety of ways, the most usual of which is, to plane the edges of the board quite square, that is, at right angles to the upper and under surface, and then, placing them as closely to each other as possible, to nail them down from the upper surface. Sometimes, particularly when the wood is known to be insufficiently seasoned, after the first board has been fastened down, the fourth board is secured in like manner, the two intermediate boards are then made somewhat wider than the space to receive them, and forced into their places by jumping upon them. To do this with the most ease and advantage, the intermediate boards are laid aslant, so as to be highest in the middle, and those edges which are placed together being sloped a little, so as to form rather less than a right angle with their respective upper surfaces, they are, by an adequate weight, at once compressed and levelled. The fourth board of the last series becomes the first of the next, and the operation, which is called folding the boards, is repeated till the floor is finished. The nails are driven in a little below the surface of these boards, and the cavity is filled with glazier's putty. But in rooms not intended to be carpeted, and yet where a neat and clean appearance is indispensable, the use of putty must be avoided, and the nails must not be driven in from the top. This object is obtained by dowelling the joints, that is, driving wooden pins into them in the middle of their thickness, and parallel to the surface, in the same manner as the coopers joint the boards forming the ends of their casks. In this case, one half of each pin entering the edges placed together, the boards, if the dowels be sufficiently numerous and properly placed, cannot rise or sink but in conjunction. The best place for the dowels is in the middle of the space between the joists. In the best dowelled work, the nails are concealed when the floor is finished, for they are driven in slantwise through the outer edge only of each board. Sometimes the joints of flooring boards are rabbeted, that they may lap over each other a little way, and sometimes toothed into each other, or, as it is technically expressed, ploughed and tongued. When either of these methods is adopted, the boards are not separated on their contraction so as to leave an aperture between each pair, through which any thing can drop; but such floors are more costly than others, not only on account of the extra labour, but the greater quantity of wood which they require.

It is always desirable to cover a floor with boards in one length; but when it cannot be done, the ends of the two boards should invariably be upon a joist, and two of them should never be together in the same line.

Yellow deal, well seasoned, is one of the best woods that can be selected for floors: the white sort, by frequent washing, becomes blackish and disagreeable in its appearance.

In the habitations of the labouring classes of society, the ground floors are often made of a kind of mortar. The best materials for this purpose are two-thirds of lime, one of coal-ashes, and a small portion of clay. These ingredients are to be well tempered with water, left to subside for a week or ten days, and then well worked up again. This operation should be repeated in the course of three or four days, till the mixture becomes smooth and glutinous, when it is fit for use. It is to be aid on to the depth of two and a half or three inches, and carefully smoothed with a trowel. The hottest season of the year is the most proper for applying this composition, which, when completely dried, will make a most durable floor.

XVIII. *Proportions of Timbers, &c.*—In the treatise entitled the "British Carpenter," already referred to, are given the following Tables to shew the proportions of timbers for small and large buildings.

Proportions of Timbers for Small Buildings.

Bearing Posts of Fir.

Height	Scantling
if 8 feet	4 inc. square
10	5
12	6

Bearing Posts of Oak

Height	Scantling
if 10 feet	6 inc. square
12	8
14	10

Girders of Fir.

Bearing	Scantling	
if 16 feet	8 in. by	11
20	10	12½
24	12	14

Girders of Oak.

Bearing	Scantling	
if 16 feet	10 inc. by	13
20	12	14
24	14	15

Joists of Fir.

Bearing	Scantling	
if 6 feet	5 inc. by	2½
9	6½	2½
12	8	2½

Joists of Oak.

Bearing	Scantling	
if 6 feet	5 inc. by	3
9	7½	3
12	10	3

Bridgings of Fir.

Bearing	Scantling	
if 6 feet	4 inc. by	2½
8	5	2¾
10	6	3

Bridgings of Oak.

Bearing	Scantling	
if 6 feet	4 inc. by	3
8	5½	3
10	7	3

Small Rafters of Fir.

Bearing	Scantling	
if 8 feet	3½ inc. by	2½
10	4¾	2
12	5½	2½

Small Rafters of Oak.

Bearing	Scantling	
if 8 feet	4½ inc. by	3
10	5½	3
12	6½	3

Beams of Fir, or Ties.

Length	Scantling	
if 30 feet	6 inc. by	7
45	9	8½
60	12	11

Beams of Oak, or Ties.

Length	Scantling	
if 30 feet	7 inc by	8
45	10	11½
60	13	15

Principal Rofters of Fir.

	Scantling			
Length	Top		Bottom	
if 24 feet	5 ins. & 6		6 ins. & 7	
36	6½	8	8	10
48	8	10	10	12

Principal Rafters of Oak.

	Scantling			
Length	Top		Bottom	
if 24 feet.	7 ins. & 8		8 ins. & 9	
36	8	9	9	10½
48	9	10	10	12

Proportions of Timbers for Large Buildings.

Bearing Posts of Fir.

Height	Scantling
if 8 feet	5 inc. square
12	8
16	10

Bearing Posts of Oak.

Height	Scantling
if 8 feet	8 inc. square
12	12
16	16

Girders of Fir.

Bearing	Scantling	
if 16 feet	9½ inc. by	13
20	12	14
24	13½	15

Girders of Oak.

Bearing	Scantling	
if 16 feet	12 inc. by	14
20	15	15
24	18	16

Joists of Fir.

Bearing	Scantling	
if 6 feet	5 inc. by	3
9	7½	3
12	10	3

Joists of Oak.

Bearing	Scantling	
if 6 feet	6 inc. by	3
9	9	3
12	12	3

Bridgings of Fir.

Bearing	Scantling	
if 6 feet	4 inc. by	3
8	5½	3
10	7	3

Bridgings of Oak.

Bearing	Scantling	
if 6 feet	5 inc. by	3½
8	6½	3½
10	8	3½

Small Rafters of Fir.

Bearing	Scantling	
if 8 feet	4½ inc. by	3
10	5½	3
12	6½	3

Small Rafters of Oak.

Bearing	Scantling	
if 8 feet	5½ inc. by	3
10	7	3
12	9	3

Beams of Fir, or Ties.

Length	Scantling	
if 30 feet	7 inc. by	8
45	10	11½
60	13	15

Beams of Oak, or Ties.

Length	Scantling	
if 30 feet	8 inc. by	9
45	11	12
60	14	16

Principal Rafters of Fir.

	Scantling			
Length	Top		Bottom	
if 24 feet	7 ins. & 9		8 ins. & 9	
36	8	9	9	10½
48	9	10	10	12

Principal Rafters of Oak.

	Scantling			
Length	Top		Bottom	
if 24 feet	8 ins. & 9		9 ins. & 10	
36	9	10	10	12
48	10	13	12	14

The author of the preceding tables observes, that though they seem so plain as not to require explanation, yet a few remarks might be subjoined with propriety. All binding or strong joists, he then adds, ought to be half as thick again as common joists; that is, if a common joist be given three inches thick, a binding joist should be four inches and a half thick, although of the same depth.

If it be not convenient to allow the posts in partitions to be square, which is the best form, in such cases, multiply the square of the side of the posts, as here given, by itself: for instance, if it be six inches square, then as six times six is thirty-six, to keep this post nearly to the same strength, find two numbers producing the same amount; as suppose the partition to be four inches thick, then let the post be nine inches the other way, so that nine times four being thirty-six, the area of its horizontal section is the same, and its strength nearly equal to the square post.

Posts that go to the height of two or three stories, need not hold the proportions given in the table, because at every floor they meet with a tie. Admit a post to be thirty feet high, and that in this height there are three stories, two of ten feet and one of eight feet: look for posts of fir ten feet high, their scantling is five inches square, that is, twenty-five square inches which double for the two stories; and also take that of eigh feet high, being four inches, that is, sixteen inches square, all which being added together, make sixty-six inches; so that such a post would be rather more than eight inches square. On occasion it may be lessened in each story as it rises.

All beams, ties, and principal rafters, ought to be cut or forced in framing to a camber, or roundness, on the upper side, and the convexity may be about one inch in eighteen or twenty feet. The reason is, that all timber, partly from its own weight, but principally from the weight of the covering or other burden it has to bear, will swag; and unless prepared in this manner, that it may never become concave, a degree of unsightliness, and often of inconvenience, will be produced.

The joists in floors, the purlines, (or timbers into which the small rafters are tenoned in roofs,) &c. should not exceed twelve feet in the length of their bearing, or from support to support. The strong joists of floors should not be at a greater distance than five feet, nor common joists more than ten or twelve inches apart.

According to the experiments of Muschenbroek, fir is able to bear compression in the direction of the length of its fibres, or to sustain as a post, a much greater weight than oak, but is far inferior to oak when the weight is suspended. In the preceding tables, therefore, the scantlings of fir bearing posts and principal rafters are properly made *less* than those of oak; but for other timbers, particularly for ties, many are of opinion that the proportions of the author's tables should be reversed, and the scantling which he has assigned to fir should be given to oak.

XIX. Building Act.—All the buildings erected in London and the several parishes within the bills of mortality, are subjected to the regulations of an act of parliament, of the 14 Geo. III. the main object of which is to lessen the danger to be apprehended from fire. As many of the provisions of this act are of great importance, and deserve to be universally known and acted upon, we shall conclude the subject of Building by an abstract of them. Those which relate to the Carpenter are the following:

Timber partitions between building and building, erected or erecting before the passing of the act, may remain till one of the adjoining houses is rebuilt, or till one of the fronts, or two-thirds of the fronts which abut on such timber partition, is taken down to the bressummer, or one pair of stairs floor, and rebuilt.

Three months' notice of the pulling down of such wooden partition, when decayed or of insufficient thickness, to be given by the proprietor to the owner or occupier of such a house, and if the house be empty, such notice to be stuck up on the front or front door of it.

No timber hereafter to be laid in any party arch, or party wall, except for bond to the same; nor any bond timber within nine inches of the opening of a chimney, nor within five inches of the flue; nor any timber within two feet of any oven, stove, copper, still, boiler, or furnace.

The wood work of chimney breasts to be fastened to the said breast with iron wall hooks, spikes, nails, or holdfasts, which must not be driven more than three inches into the wall, or nearer than four inches to the inside of the opening of the chimney.

No timber bearer to wooden stairs let into an old party wall, must come nearer than eight inches and a half to the flue, nor nearer than four inches to the internal finishing of the adjoining building.

No timber to be laid under any hearth to a chimney, nearer than eighteen inches to the upper surface of such hearth.

No timber must be laid nearer than eighteen inches to any door of communication through the party walls of warehouses and stables.

Bressummers, story posts, and plates thereto, are only permitted in the ground story, and may stand even with the outside of the wall, but must go no deeper than two inches into a party wall, nor nearer than seven inches to the centre of a party wall, when it is two bricks thick, nor nearer than four inches and a half, provided the party wall does not exceed one brick and a half in thickness.

Every corner story post must be of oak, and at least twelve inches square, when employed for the support of two fronts.

Window frames and door frames to the first, second, third, and fourth rate classes, are to be recessed in reveals, four inches at least.

Door-cases and doors to warehouses only of the first, second, third, or fourth rate classes, may be even with the outward face of the wall.

No external decoration to be of wood, except cornices or dressings to shop windows; frontispieces to door-ways of the second, third, and fourth rate classes, and covered ways or porticoes to buildings; but not to project beyond the original line of the house in any street or way. Such covered way or portico not to be covered with wood; nor such cornice, covered way, or roof of the portico, to be higher than the under side of the sill to the windows of the one pair of stairs floor. No flat gutter or roof, nor any turret, dormer, or lantern light, or other erection placed on the flat of the roof belonging to the first, second, third, fourth, and fifth rate classes, to be of wood.

No wooden water tanks must be higher from the ground than the tops of the windows of the ground story.

Those provisions of the act which relate to the Bricklayer are the most numerous. Every master bricklayer must give twenty-four hours' notice to the surveyor of the district, concerning the building to be altered or erected; but if the building is to be piled or planked, or begun with wood, it becomes the business of the carpenter to give such notice.

The footings of the walls are to have equal projections on each side; but where any adjoining building will not admit of such projections to be made on the side adjoining to such building, this direction to be complied with as nearly as possible.

The timbers in each rate, as girders, beams, trimming joists, &c. may have as much bearing as the nature of the wall will admit, provided four inches be left between the ends of such timber and the external surface of the wall.

XX. *External Walls.*—Every front, side, or end wall, not being a party wall, is called an external wall.

External walls, and other external enclosures to the first, second, third, fourth, and fifth rates of buildings, must be of brick, stone, artificial stone, lead, copper, tin, slate, tile, or iron; or of some or all of these materials in conjunction, except the planking, piling, &c. for the foundation, which may be of wood.

If any part to an external wall of the first and second rate is built wholly of stone, it is not to be less in thickness than as follows: first rate, fourteen inches below the ground floor, nine inches above the ground floor; second rate, nine inches above the ground floor.

Where a recess is meant to be made in an external wall, it must be arched over, in such a manner, that the arch and the back of such recess shall respectively be of the thickness of one brick in length; hence no walls are allowed to be recessed which are not more than one brick in thickness.

No external wall to the first, second, third, and fourth rate, is ever to become a party-wall, unless the same shall be of the height and thickness above the footing, as is required for each party-wall to its respective rate.

XXI. *Party-Walls.*—Buildings of the first, second, third, and fourth rate, which are not yet designed by the owner thereof to have separate and distinct side walls, on such parts as may be contiguous to other buildings, must have party-walls; and they are to be placed half and half on the ground of each owner, or of each building respectively, and may be built thereon, without any notice being given to the owner of the other part, the first builder having a right so to do, when building against vacant ground.

Party-walls, chimneys, and chimney shafts hereafter to be built, must be of good sound brick or stone, or of sound bricks and stone together, and must be coped with stone, tile, or brick.

Party-walls, or additions thereto, must be carried up thirteen inches above the roof, measuring at right angles with the back of the rafter, and twelve inches above the gutter of the highest building which gables against it; but where the height of a party-wall so carried up, exceeds the height of the blocking course or parapet, it may be made less than one foot above the gutter, for the distance of two feet six inches from the front of the blocking course or parapet.

Where dormers (the term for windows in roofs, differing from sky-lights by their being vertical) or other erections are fixed in any flat or roof, within four feet of any party-wall, such party-wall is to be carried up against such dormer, and must extend at least two feet wider, and to the full height of every such dormer or erection.

No recess is to be hereafter made in any party-wall of the first, second, third, and fourth rate, except for chimney flues, girders, &c. and for the ends of walls or piers, so as to reduce such wall in any part of it to a less thickness than is required by the act, for the highest rate of building to which such wall belongs.

No opening is to be made in any party-wall, except for communication from one stack of warehouses to another, and from one stable building to another, and the communications allowed must have wrought iron doors, and the pannels thereof are not to be less than a quarter of an inch thick, and must be fixed in stone door-cases and sills. But there may be openings for passages or ways on the ground, for foot passengers, cattle, or carriages, which must be arched over throughout with brick or stone, or brick and stone together, of the thickness of a brick and a half at the least, to the first and second rate, and one brick to the third and fourth rate. And if there is any cellar or vacuity under such passage, it is to be arched over throughout in the same manner as the passage over it.

No party wall, or party-arch, or shaft of any chimney, new or old, must be cut into, except for the following purposes: if the fronts of buildings are in a line with each other, a recess may be cut, both in the fore and back front of such buildings, (as may be already erected,) for the purpose of inserting the end of such other external wall, which is to adjoin thereto. This recess must not be more than nine inches deep from the outward faces of such external walls, and not be cut beyond the centre of the party-wall. And for the purpose of inserting bressummers and story-posts, that are to be fixed on the ground floor, either in the front or back wall, the recess may be cut from the foundation of such new wall to the top of such bressummer, fourteen inches deep from the outward face of such wall, and four inches wide in the cellar story, and two inches wide on the ground story. The same may also be done for the purpose of tailing-in stone steps, or stone landings, as for bearers to wood stairs, or for laying-in stone corbels for the support of chimney jambs, girders, beams, purlines, binding or trimming joists, or other principal timbers.

Perpendicular recesses may also be cut in any party-wall, whose thickness is not less than thirteen inches, for the purpose of inserting walls and piers therein; but they must not be wider than fifteen inches, or more than four inches deep; and no such recess is to be nearer than ten feet to any other recess. All such cuttings or recesses must be immediately made good, and effectually pinned up, with brick, stone, slate, tile, shell, or iron, bedded in mortar.

No party wall must be cut for any of the above purposes, if the same will injure, displace, or endanger the timbers, chimneys, flues, or internal finishings of the adjoining buildings.

The footing may be cut off on the side of any party-wall, where an independent side wall is intended to be built against such party-wall.

When any buildings (inns of court excepted) that are erected over gate-ways, or public passages, or have different rooms and floors, the property of different owners, are to be rebuilt, they must have a party-wall, with a party-arch or arches of the thickness of a brick and a half at the least, to the first and second rate, and of one brick to the third and fourth rate, between building and building, or between the different rooms and floors that are the property of different owners.

Inns of court are required only to have party-walls where any room or chamber communicates to each separate and distinct staircase, and which are also subject to the same regulations as respect other party-walls.

If buildings of different rates adjoin each other, and any addition is intended to be made to the lower rate, the party-wall of such building must be such as is required for that of the higher rate adjoining.

When any party-wall is raised, it is to be made of the same thickness as the wall in the story next below the roof of the highest building adjoining, but it must not be raised at all, unless it can be done with safety to such wall, and the building adjoining thereto.

Every dwelling-house built four stories high from the foundation, exclusive of rooms in the roof, must have its party-wall built according to the third rate, although such dwelling-house may be of the fourth rate. Every dwelling-house, also, exceeding four stories in height from the foundations, exclusive of the rooms in the roof, must have its party-wall built according to the first rate, although such house may not be of the first rate.

XXII. *Chimneys.*—No chimney is to be erected on timber, except on the piling, planking, &c. of the foundations of the building.

Chimneys may be built back to back in party-walls; but when this is done, they must not be less in thickness from the centre of such party-wall than as follows: first rate, or adjoining thereto, must be one brick thick in the cellar story, and half a brick in all the upper stories. Second, third, and fourth, rate, or adjoining thereto, must be three-quarters of a brick in the cellar story; and half a brick in all the upper stories. Such chimneys in party-walls of any of the four rates, as do not stand back to back, may be built as follows; from the external face of the party-wall to the inward face of the back of the chimney in the cellar story, one brick and a half thick, and in the upper stories, one brick thick from the hearth to twelve inches above the mantle. If such chimney is built against any other wall, the back may be half a brick thinner than above stated.

Those backs of chimneys which are not in party-walls of the second, third, and fourth rate, must be in every story one brick thick at least, from the hearth to twelve inches above the mantle. These backs may also be half a brick thinner, if such chimney be built against any other wall.

The breasts of chimneys, whether in party-walls or not, are not to be less than one brick thick in the cellar story, and half a brick thick in every other story.

All partitions between flues must not be less than half a brick thick.

Flues may be built opposite to each other in party walls, but they must not approach nearer to the centre of such wall than two inches.

All chimney breasts next to the rooms, and chimney backs, and all flues, are to be rendered or pargeted.

Backs of chimneys, and flues in party-walls against vacant ground, must be lime whited, or marked in some durable manner, but must be rendered or pargeted as soon as any other building is erected to adjoin them.

No timber must be over the opening of any chimney for supporting the breast; but all chimneys must have a brick or stone arch, or iron bar or bars.

All chimneys must have slabs or foot paces of stone, marble tile, or iron, at least eighteen inches broad, and at least one foot longer than the opening of the chimney when finished, and such slabs or foot paces must be laid on brick or stone trimmers at least eighteen inches broad from the face of the chimney breast, except there be no room or vacuity beneath, in which case they may be bedded on the ground.

Brick funnels must not be made on the outside of the first, second, third, or fourth rate, next to any street, square, court, road, or way, so as to extend beyond the general line of the building in such situations.

No metallic funnel or other pipe, for conveying smoke or steam, is allowed to be fixed near any public street, square, court, or way to the first, second, third, or fourth rate, and no such pipe is to be fixed on the inside of any building nearer than fourteen inches to any timber, or other combustible material.

House. Every man's house is as his castle, as well to defend him against injuries, as for his repose. Upon recovery in any real action or ejectment, the sheriff may break the house and deliver seisin, &c. to the plaintiff. Where the king is party, the sheriff may break the party's house to take him, or to execute other process of the king; but he ought first to signify the cause of his coming, and request the door to be opened; when the door is open, the sheriff may enter and make execution at the suit of any subject; but where the door is shut, there he cannot break it to execute process at the suit of a subject. Though a house is a castle for the owner himself and his family and his own goods, &c. yet it is no protection for a stranger flying thither; or the goods of such a one to prevent lawful executions, nor for persons guilty of high treason, or breaches of the peace. A man ought so to use his house as not to damnify his neighbours.

HOUSED, at sea, expresses the situation of the great guns upon the middle and lower decks when they are run in, and the breech being let down, the muzzle rests against the side above the port: they are then secured by their tackles, muzzle lashes, and breechings.

HOVERING, in Law. Ships of fifty tons, laden with customable or prohibited goods, hovering on the coasts of this kingdom, within the limits of any port (and not proceeding from foreign parts) must take a security in such sum of money to the amount of treble the value of such foreign goods then on board, that such ship shall proceed, as soon as wind and weather, and the condition of the ship, will permit, on her voyage to foreign parts.

HUE and CRY, is the ancient common law process after felons, and such as have dangerously wounded any person, or assaulted any one with intent to rob him. For the levying of hue and cry, although it is a good course to have a justice's warrant, where time will permit, in order to prevent causeless hue and cry; yet it is not necessary, nor always convenient; for the felon may escape before the warrant be obtained.

HUER, or Hver, the Icelandic name for streams of heated water, which are forced with great violence through apertures in the earth, by internal causes, to a great height, in that island.

HUGUENOTS, a term of contempt, first given to the French protestants, in the year 1560. This term probably owes its origin to an erroneous pronunciation of the German word Eidgenossen, which signifies *sworn-fellows*. This had been the name of that part of the Genevans who entered into an alliance with the Swiss cantons, in order to maintain their liberties against the Duke of Savoy. The name is also said to have been derived from a gate of the city in which they first assembled.

HUMANITIES, in the plural, signify grammar, rhetoric, and poetry, known by the name of *literæ humaniores*.

HUMIDITY. *See* Hygrometer.

HUMULUS, in Botany, a genus of the dioecia pentandria class and order. There is but one species, *viz.* H. lupulus, *Hops*, which see.

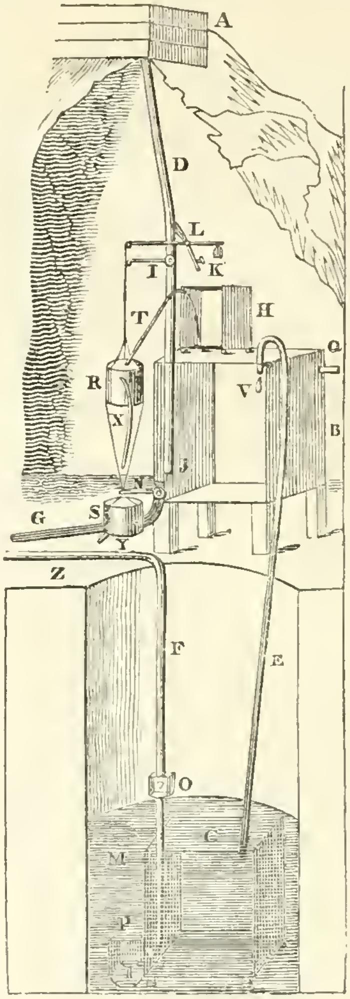
HUNDRED, a number equal to 10 times 10, denoted by the Roman letter C, and written thus, 100. *Hundred weight*, a measure of weight equal to 112lbs. and commonly denoted by the contraction *cwt.*

Hundred. Hundreds are not answerable to persons robbed, travelling on a Sunday: but are liable to penalty on exportation of wool: to damages sustained by pulling down buildings, killing cattle, cutting down trees, burning houses, &c., destroying turnpikes or works on navigable rivers; cutting hop-binds, destroying corn to prevent exportation, and by wounding officers of the customs. All moneys recovered against the hundred to be levied by a rate.

HUNGARIAN Machine, an hydraulic engine, is a very ingenious application of the *Hero Jet d' Eau* principle. The following engraving represents this machine. A is the source of water elevated 136 feet above the mouth of the pit, and from this source there descends a pipe D of 4 inches diameter, which enters the crown of a copper cistern B, 8½ feet high, 5 feet diameter, and 2 inches thick. The pipe D reaches to within 4 inches of the bottom of this copper cistern; it has a cock at I.

This cistern has a cock at Q, and a very large one at N; from its top proceeds a pipe V E C two inches diameter, which goes down the pit 96 feet, and is inserted into the top of another brass or copper cistern C, 6¼ feet high, 4 feet diameter, and 2 inches thick; the latter containing nearly 83 cubic feet, which is about half the capacity of the former, *viz.* 170 cubic feet. Another pipe, F O, 4 inches diameter, rises from within 4 inches of the bottom of this lower cistern, is soldered into its top, and rises to the trough Z, which carries off the water from the mouth of the pit. This lower cistern communicates at the bottom with the water O, which collects in the drains of the mines. A large cock P serves to exclude or admit this water; another cock M, at the top of this cistern, communicates with the external air.

Now, suppose the cock I shut, and all the rest open; the upper cistern will contain air, and the lower cistern will be filled with water, because it is sunk so deep that its top is below the usual surface of the mine-waters. Shut the cocks Q, N, M, P, and open the cock I. The water of the source A must run in by the orifice J, and rise in the upper cistern, compressing the air above it, and along the pipe V E C and thus acting on the surface of the water in the lower cistern. It will therefore cause it to rise gradually in the pipe O F, where it will always be of such a height that its weight balances the elasticity of the compressed air. Suppose no issue given to the air from the upper cistern, it would be compressed into one-fifth of its bulk by the column of 136 feet high; for a column of 34 feet nearly balances the ordinary elasticity of the air. Therefore, when there is an issue given to it through the pipe V E C, it will drive the compressed air along this pipe, and it will expel water from the lower cistern. When the upper cistern is full of water, there will be 34 cubic feet of water expelled from the lower cistern. If the pipe O P had been more than 136 feet long, the water would have risen 136 feet, being then in equilibrio with the water in the feeding pipe D, by the intervention of the elastic air; but no more water would have been expelled from the lower cistern than what fills this pipe. But the pipe being only 96 feet high, the water will be thrown out at Z with a considerable velocity. If it were not for the great obstructions which water and air must meet with in their passage along pipes, it would issue at Z with a velocity of more than fifty feet per second. It issues however much more slowly, and at last the upper cistern is full of water, and the water would enter the pipe V E and enter the lower cistern, and, without displacing the air in it, would rise through the discharging pipe O P, and run off to waste. To prevent this, there hangs in the pipe V E a cork ball or double cone, by a brass wire which is guided by holes in two cross-pieces in that pipe. When the upper cistern is filled with water, this cork plugs up the orifice V, and no water is wasted; the influx at J now stops. But the lower cistern contains compressed air, which would balance water in a discharging pipe 136 feet high, whereas O P is only 96. Therefore the water will continue to flow at Z till the air has so far expanded as to balance only 96 feet of water, that is, till it occupies one-half of its ordinary bulk, that is, one-fourth of the capacity of the upper cistern, or 42½ cubic feet. Therefore 42½ cubic feet will be expelled, and the efflux at Z will cease; and the lower cistern is about one-half full of water. When the attending workman observes this, he shuts the cock I. He might have done this before, had he known the orifice V was stopped; but no loss ensues from the delay. At the same time the attendant opens the cock N the water issues with great violence, being pressed by the condensed air from the lower cistern. It therefore issues with the



sum of its own weight and of this compression. These gradually decrease together, by the efflux of the water and the expansion of the air; but this efflux stops before all the water has flowed out; for there are 42½ feet of the lower cistern occupied by air. This quantity of water remains, therefore, in the upper cistern nearly: the workman knows this, because the discharged water is received first of all into a vessel containing three-fourths of the capacity of the upper cistern. Whenever this is filled, the attendant opens the cock P by a long rod which goes down the shaft; this allows the water of the mine to fill the lower cistern, and the air to get into the upper cistern, which permits the remaining water to run out of it. Thus every thing is brought into its first condition; and when the attendant sees no more water come out at N, he shuts the cocks N and M, and opens the cock I, and the operation is repeated.

There is a very surprising appearance in the working of this engine. When the efflux at Z has stopped, if the cock Q be opened, the water and air rush out together with prodigious violence, and the drops of water are changed into hail or lumps of ice. It is a sight usually shewn to strangers, who are desired to hold their hats to receive the blasts of air: the ice comes out with such violence as frequently to pierce the hat like a pistol bullet. This rapid congelation is a remarkable instance of the general fact, that air by suddenly expanding generates cold, its capacity for heat being increased.

Now, from the above account of the procedure in working this engine, we see that the efflux both at Z and N becomes very slow near the end. It is found convenient therefore not to wait for the complete discharges, but to turn the cocks when about 30 cubic feet of water have been discharged at Z; more work is done in this way. A gentleman of great accuracy and knowledge of these subjects took the trouble of noticing particularly the performance of the machine. He observed, that each stroke took up about three minutes and one-eighth; and that 32 cubic feet of water were discharged at Z, and 66 were expended at N. The expense therefore is 66 feet of water falling 136 feet, and the performance is 32 raised 96, and they are in the proportion of 66 × 136 to 32 × 96, or of 1 to 0.3422, or nearly as 3 to 1. This, says Dr. Gregory, is superior to the performance of the most perfect undershot mill, even when all friction and irregular obstructions are neglected; and is not much inferior to any overshot pump-mill that has yet been erected. When we reflect on the great obstructions which water meets with in its passage through long pipes, we may be assured, that by doubling the size of the feeder and discharger, the performance of the machine will be greatly improved; we do not hesitate to say, that it would be increased one-third: it is true that it will expend more water; but this will not be nearly in the same proportion, for most of the deficiency of the machine arises from the needless velocity of the first efflux at Z. The discharging pipe ought to be 110 feet high, and not give sensibly less water. Then it must be considered how inferior in original expense this simple machine must be to a mill of any kind which would raise 10 cubic feet 96 feet high in a minute, and how small the repairs on it need be, when compared with a mill. And, lastly, let it be noticed that such a machine can be used where no mill whatever can be put in motion. A small stream of water, which would not move any kind of wheel, will here raise one-third of its own quantity to the same height; working as fast as it is supplied.

For these reasons, we join in opinion with Dr. Gregory, that the Hungarian machine eminently deserves the attention of the mathematicians and engineers, to bring it to its utmost perfection, and into general use. There are situations where this kind of machine may be very useful. Thus, where the tide rises 17 feet, it may be used for compressing air to seven-eights of its bulk; and a pipe leading from a very large vessel inverted in it may be used for raising the water from a vessel of one-eighth of its capacity 17 feet high; or if this vessel has only one-tenth of the capacity of the large one set in the tide-way, two pipes may be led from it; one into the small vessel, and the other into an equal vessel 16 feet higher, which receives the water from the first. Thus one-sixteenth of the water may be raised 34 feet, and a smaller quantity to a still greater height; and this with a kind of power that can hardly be applied any other way. Machines of this kind should not be forgotten, because opportunities may offer of making them highly beneficial, where other circumstances might dictate their erection.

Mr. J. W. Boswell has devised an apparatus, which when attached to such a machine as that at Chemnitz, enables it to work itself without attendance. See the foregoing figure.

A, is the reservoir, or upper level of water.

B, a chamber or cistern made of sufficient strength to bear the internal pressure of a column of water the height of A above it, multiplied by its own base.

C, a chamber of the same strength as B, but of a smaller size; it is placed at the bottom of the pit from which the water is to be raised, and under the level of the water. These chambers would be stronger with the same materials, if of a globular or cylindrical form; but the square shape is used in the drawing, merely for the facility of representing the position of the parts.

D, a pipe from the reservoir A, which passes through the top of B, and ends near its bottom, to convey water from A to B.

E, a pipe from the top of B to the top of C, to convey air from B to C.

F, a pipe from the bottom of C to the level of the ground at the top of the pit, to carry off the water from the pit.

G, a pipe from the bottom of B to carry off the water from it.

H, a vessel to contain the water used in working the cocks; it is only placed on the top of B to save the construction of a stand on purpose for it.

I, a cock, or moveable valve (worked by the lever there represented) in the large pipe D.

N, a stop-cock in the small pipe which conveys water from D to H. Its use is to make the engine work faster or slower, by letting water more or less quick into H; or to stop it altogether from working when required.

L, a moveable valve or cock in the small pipe L K. The lever which works it is connected by a strong wire with the lever which works I, and is balanced by a weight at its opposite extremity, sufficient to open both these cocks and shut N, when not prevented by a counter-weight.

N, a cock in the pipe G to open and shut it as wanted.

G, a self-moving valve in the pipe F, which permits the water to pass upwards, but prevents its return.

P, a self-moving valve at the bottom of C, which permits the water to pass into C, but prevents any from passing out of it; it is furnished with a grating, to prevent dirt getting in.

R, a vessel suspended from the levers of I and L, capable of containing a weight of water sufficient to shut them.

S, a vessel suspended from the lever of N: it must contain water enough by its weight to open N: it is connected by a chain to R, to keep it down as long as N is open.

T, a syphon passing from the bottom of H, near its upper edge, and down again to the mouth of R.

V, a self-moving valve of a sufficient levity to rise, when the water in B comes up to it, and close the pipe E; into which no water would else pass from B. A ball-cock, such as is used in common water cisterns, would do here.

X, a syphon from the bottom of R, rising within an inch of its top, and passing down again to the mouth of S.

Y, a small pipe at the bottom of S: this may have a stop-cock to regulate it, which, when stopped, will also stop the engine.

The mode of this engine's working is as follows: Suppose the vessels V, H, R, and S, empty of water, and the cocks K and Y open, and the vessel C full of water. The weight on the lever of L will then open the cocks L and I, on which the water from A will flow into B and H. As the water rises in B, it will force the air through E into C, which strongly pressing on the water in C, will force it up through the pipe F, till the water in B rises to the lever of V and closes it, at which time it will be full of water, (the quantity flowing in being so regulated by the cock K,) and the water will flow from it through the syphon T into the vessel R, which, as it fills, shuts the cocks I and L, and prevents any more water coming into B and H. When R is full, the water flows through its syphon X, which fills S, and by it opens N, which empties B of water, and keeps N open as long as there is any water in H.

When H is empty, B will be so too, (being so regulated by the cock K) on which, in a moment or two, R and S will also be empty; which will cause the cocks I and L to open, and all things will be again in the state first supposed, for a repetition of the operations described.

To stop the engine, the cocks at K and Y should be shut, while S is full of water. To set it working, they should be open; and this is all the attendance it will require. As no one but an engineer should attempt to construct such an engine as this, it was useless to represent the manner of connecting the pipes by flanches, or otherwise; or the proper methods of fastening and closing the parts, which are all well known to such as have made this art their study.

HUNGARY WATER, denominated from a queen of Hungary, is made by distilling in balneo, fresh-gathered flowers of rosemary, two pounds; rectified spirits of wine, two quarts.

HURDLES, in Fortification, twigs of willows or osiers interwoven close together, sustained by long stakes, and usually laden with earth. *See* FORTIFICATION.

HURDLES, in Husbandry, frames of split timber, or of hazel rods wattled together, to make sheep-folds, &c.

HURRICANE, a furious storm of wind, owing to a contrariety of winds. *See* WIND and WHIRLWIND. Hurricanes are frequent in the West Indies, where they make terrible ravages, by rooting up trees, destroying houses and shipping, and the like. Hurricanes happen either on the day of the full, change, or quarter of the moon. From the unusual redness of the sun, great stillness, and at the same time turbulence of the skies, swelling of the sea, the like happening at the change of the moon, the natives conclude there will be a hurricane next full moon; and if the same signs be observed on the full moon, they expect one next new moon. As the wind betwixt the tropics is generally easterly, and upon the sun's going back from the northern tropic, the western winds pour down with violence upon those parts, the opposition of these contrary winds cannot fail to produce a hurricane. Hurricanes shift not through all the points of the compass, but begin always with a north wind, veer to the east, and then cease; and their shifting between these two points is so sudden and violent, that it is impossible for any ship to veer with it.—The importance of the barometer, as indicating the approach of hurricanes, may be learned from the following corroborative remarks on the subject, which we extract from an interesting letter to the Editor of the *South African Chronicle:* "Every one at all acquainted with the mechanism of a barometer, is aware that its construction originated in a discovery, that the mean density of the atmosphere is capable of supporting a column of mercury equal to about thirty inches in length; it follows, therefore, that every deviation from that height is the result of some change or other in the actual density or gravity of the atmosphere which supports it, the trifling effect excepted, which is produced by the attractive and cohesive qualities of the tube in which it is confined; but, although it is clear that no alteration can take place in the quicksilver, which is not occasioned by a proportional change in the weight of the atmosphere, these changes depend upon such a variety of causes, and are frequently so minute as not to be perceptible, or accompanied by any visible alteration of the weather, which is the reason why small deviations in the barometer do not always indicate any change whatever in the latter. It is a well-established fact, that the barometer undergoes little or no variation throughout the region of the tropics, except when under the influence of an approaching hurricane, when it is equally notorious that it invariably falls rapidly and considerably, as it inevitably must do, if we consider the principle upon which the quicksilver is supported in the tube, and connect it with the probable cause of these storms, which are as much exceeded in violence, as the situations in which they are generated are at most other periods in mildness, by the more boisterous climates of Europe. Of the danger attending them, (says Colonel Wright,) I have acquired some degree of knowledge from dear-bought experience, and of their approach we may at all times be warned by an infallible monitor, although I fear it is too often fatally slighted, through ignorance, perverseness, or prejudice; because that part of the ocean to which these remarks are confined is frequently sailed over without having to encounter a hurricane; and because, throughout such navigation, the barometer *may* remain almost stationary, it is too apt to be thought a useless appendage to a ship in those seas; but, so far is this from being a just conclusion, that, in my opinion, the circumstance of its not being affected by any other weather than such as is attended with imminent danger, is the strongest argument that can be adduced for its being particularly valuable in those regions. In high latitudes the experienced eye and judgment of the sailor prove a pretty correct substitute for a barometer; but the tropical hurricane, like the wolf in the fable, always comes on when least expected, so far as appearances are concerned, and therefore the barometer is the only guide to be safely confided in. My conclusion then is, after many years' experience of the navigation of those seas, as well as from theory, that, whenever the barometer is observed to fall suddenly and considerably any where within the tropics, it may be considered indubitable, that an uncommon degree of rarefaction of that part of the atmosphere is in progress, and that it will inevitably be followed by a violent reaction. Not a moment, therefore, is to be lost in bringing the ship to wind, and preparing her for a storm; from that moment the ship has passed the circumference of a circle, the centre of which is the centre of danger, inasmuch as it is the centre of the atmospheric expansion. I think I may fairly conclude, that the barometer will infallibly indicate the approach of a hurricane within the tropics, and that where the storm commences, there will it first subside, and there will it be most moderate: and if this be the truth, one would almost think it were an instrument placed by Providence in the hands of sailors to warn them of their danger; for if they are to proceed in their course, in defiance of such warning, the barometer might as well be on shore. The sailor is an amphibious animal, and there being something peculiar in the disposition of animals which partake of a twofold nature, I recommend, in conclusion, that those gentlemen and ladies from the East, who have recourse to our salubrious climate for the purpose of repairing their shattered constitutions, should never, but when it cannot be avoided, engage a passage in a ship that is not possessed of one, and that they should keep guard over its silent salutary warnings themselves."

HUSBAND and WIFE, usually termed *baron* and *feme*, are one person in law; that is, the very being or legal existence of the woman is suspended during the marriage; or, at least, is incorporated and consolidated into that of the husband, under whose wing, protection, and cover she performs every thing; she is therefore called, in our law, (French,) a feme covert, that is, under the protection and influence of her husband, her baron, or lord; and her condition, during her marriage, is called her coverture. A man cannot grant lands to his wife during the coverture, nor any estate or interest to her, nor enter into covenant with her; but he may, by his deed, covenant with others for her use, as for her jointure, or the like; and he may give to her, by devise or will, because the devise or will does not take effect till after his death. All deeds executed by the wife, and acts done by her during her coverture, are void; except a fine, or the like matter of record, in which case she must be solely and secretly examined, that it may be known whether or not her act be voluntary. A wife is so much favoured, in respect of that power and authority which her husband has over her, that she shall not suffer any punishment for committing a bare theft, in company with or by coercion of her husband; but if she commit a theft of her own voluntary act, or by the bare command of her husband, or be guilty of treason, murder, or robbery, in company with or by coercion of her husband, she is punishable as much as if she were sole; because of the odiousness and dangerous consequence of these crimes. By marriage, the husband hath power over his wife's person; and the courts of law still permit a husband to restrain a wife of her liberty, in case of any gross misbehaviour; but if he threaten to kill her, &c. she may make him find security of the peace, by suing a writ of *supplicavit* out of Chancery, or by preferring articles of the peace against him, in the court of King's Bench, or she may apply to the spiritual court for a divorce, on account of cruelty. The husband, by marriage, obtains a freehold in right of his wife, if he takes a woman to wife that is seized of a freehold; and he may make a lease thereof for twenty-one years, or three lives, if it be made according to the statute 32 Henry VIII. c. 28. The husband also gains a chattel real, as a term for years, to dispose of, if he please, by grant or lease in her lifetime, or by surviving her: otherwise it remains with the wife; and upon execution for the husband's debt, the sheriff may sell the term during the life of the wife. The husband also, by the marriage, hath an absolute gift of all chattels personal, in possession of the wife in her own right, whether he survives her or not. But if these chattels personal are *choses* in action, that is, things to be sued for by action, as debts by obligation, contract, or the like, the husband shall not have them, unless he and his wife recover them.

By custom in London, a wife may carry on a separate trade; and as such, is liable to the statutes of bankruptcy, with respect to the goods in such separate trade, with which the husband cannot intermeddle. If the wife be indebted before marriage, the husband is bound afterwards to pay the debt, living with the wife; for he has adopted her and her circumstances together; but if the wife die, the husband shall not be charged for the debt of his wife after her death; if the creditor of the wife do not get judgment during the coverture. The husband is bound to provide his wife necessaries, and if she contract for them, he is obliged to pay for them; but for any thing besides necessaries he is not chargeable: and also, if a wife elope, and live with another man, the husband is not chargeable even for necessaries; at least if the person who furnish them be sufficiently apprized of her elopement. A man having issue by his wife, born alive, shall be tenant by courtesy of all the lands in fee-simple, or fee-tail general, of which she shall die seised; and after her death, he shall have all chattels real; as the term of the wife, or a lease for years of the wife, and all other chattels in possession; and also all such as are of a mixed nature, (partly in possession and partly in action,) as rents in arrear, incurred before the marriage or after; but things merely in action, as of a bond or obligation to the wife, he can only claim them as administrator to his wife, if he survive her. If the wife survive the husband, she shall have for her dower, the third part of all his freehold lands: so she shall have her term for years again, if he have not altered the property during his life: so also she shall have again all other chattels real and mixed; and so things in action, as debts, shall remain to her, if they were not received during the marriage: but if she elope from her husband, and go away with her adulterer, she shall lose her dower; unless her husband had willingly, without coercion ecclesiastical, been reconciled to her, and permitted her to cohabit with him.—*Watkins's Cyclopædia.*

HUSBAND, *Ship's*, the owner, who takes the direction and management of a ship's concern upon himself, the other owners paying him a commission for his trouble.

HUSBANDRY, or AGRICULTURE, is the science which explains the means of making the earth produce, in plenty and perfection, those vegetables which are necessary to the subsistence of man, and of the animals reared by him for food or labour. To explain the various branches of this important article would require a volume, or an extended account which our pages cannot admit. To the agriculturist we would recommend Townes's Farmer's Directory, as a work replete with valuable information.

HUSTINGS, a court held before the Lord Mayor and Aldermen of London. Error on attaint lies there of a false verdict in the sheriff's court.

HUYGENS, a very celebrated Dutch mathematician and astronomer, who flourished in the 17th century. He has been chiefly distinguished for making improvements in the telescope, the air pumps, and pendulums.

HYÆNA, in Natural History, an animal remarkable for its untameable ferocity. It is chiefly an inhabitant of the most solitary regions of the torrid zone.

HYBERNACULUM, that part of the plant which defends the embryo plant from injuries during winter.

HYDRA POLYPES, in Natural History, a genus of the vermes zoophyta class and order; an animal fixing itself by the base, linear, gelatinous, naked, contractile, and furnished with setaceous feeders; inhabiting fresh waters, and producing its deciduous offspring or eggs from the sides. There are five species. When a polype is cut transversely, or longitudinally, into two or three parts, each part in a short time becomes a perfect animal; and so great is this prolific power, that a new animal will be produced even from a small portion of the skin of the old one. If the young ones be mutilated while they grow upon the parent, the parts so cut off will be reproduced; and the same property belongs to the parent. A truncated portion will send forth young ones before it has acquired a new head and tail of its own, and sometimes the head of the young one supplies the place of that which should have grown out of the old one. If we slit a polype longitudinally through the head to the middle of the body, we shall have one formed with two heads; and by again slitting these in the same manner, we may form one with as many heads as we please. A still more surprising property of these animals is, that they may be grafted together. If the truncated portions of a polype be placed end to end, and gently pushed together, they will unite into a single one. The two portions are first joined together by a slender neck, which gradually fills up and disappears, the food passing from one part into the other; and thus we may form polypes, not only from different portions of the same animal, but from those of different animals. We may fix the head of one to the body of the other, and the compound animal will grow, eat, and multiply, as if it had never been divided. By pushing the body of one into the mouth of another, so far that their heads may be brought into contact, and kept in that situation for some time, they will at last unite into one animal, only having double the usual number of arms. The hydra fusca may be turned inside out like a glove, at the same time that it continues to eat and live as before. The lining of the stomach now forms the outer skin, and the former epidermis constitutes the lining of the stomach.

HYDRA, *the Female Snake*, is an immense constellation of the Southern hemisphere, extending for above 100 degrees from the west to east, beneath the Crab, the Lion, and the Virgin. This constellation is said to represent the water serpent destroyed by Hercules. The origin of the Celestial Snake is as doubtful as that of the Crow or the Cup; for another fable tell us that Apollo, intending to offer a sacrifice to Jupiter, sent a crow with a cup for some water; but the bird having amused itself otherwise than it had been bidden, and returning without its errand, excused itself to the god, by affirming that the stream into which it wished to dip the cup was guarded by an enormous serpent. Apollo, to punish the falsehood of the crow, placed it opposite to the cup, and charged the serpent not to allow it to drink.

The boundaries and contents of this constellation are:—North by the zodiacal signs Cancer, Leo, and Virgo; west by Monoceros; south by Argo Navis, Antlia Pneumatica, and Centaurus; and east by Lupus and Scorpio. There are sixty stars in this constellation, the chief of which is Alphard, (or Cor Hydræ,) of the 2d magnitude, three of the 3d, twelve of the 4th, &c.

α Hydræ culminates at the following hours, in astronomical time, on the 1st of every month throughout the year: Merid. alt. 46° 21′ 45″.

MONTH.	CULM.			MONTH.	CULM.			MONTH.	CULM.		
	ho.	mi.	sec.		ho.	mi.	sec.		ho.	mi.	sec.
Jan.	14	30	4	May	6	45	26	Sept.	22	35	10
Feb.	12	18	16	June	4	43	5	Oct.	20	47	22
Mar.	10	29	35	July	2	39	12	Nov.	18	51	15
April	8	36	22	Aug.	0	34	39	Dec.	16	47	36

HYDRATE, in Chemistry, expresses the chemical union of water with any substance, and especially with certain metallic oxides.

HYDRAULICON, *Water Organ*, in Music, an instrument acted upon by water; the invention of which is said to be of higher antiquity than that of the wind organ.

HYDRAULICS. The science of hydraulics teaches us the method of estimating the swiftness and force of fluids in motion. Modern philosophy has dignified this science by the name of *Hydrodynamics*, or the application of *Dynamics* to the impulsion and flow of water and other liquids.

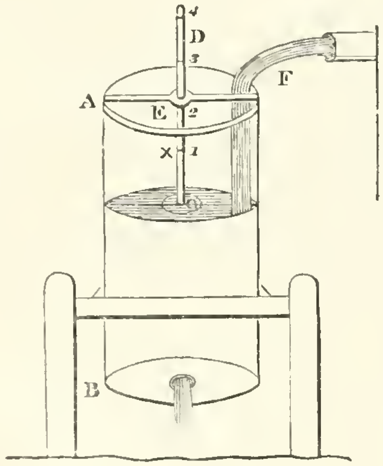
The pressure of water against the sides of vessels is increased by an increase of depth: this holds true, of water in vessels, canals, rivers, reservoirs, &c. and the proportion is as the square of the depth, or altitude. Upon the principles of this science many machines worked by water are constructed; and several different engines used in the mechanical arts, various kinds of mills, pumps, and fountains, are but applications of this theory judiciously applied.

The velocity with which water spouts from a hole at the side, or in the bottom of a vessel, is as the square root of the depth or distance of the hole below the surface of the water; for in order to make double the quantity of a fluid run through one hole as through another of the same size, it will require four times the pressure of the other, and therefore the aperture must be four times the depth of the other below the surface of the water; and for the same reason, three times the quantity running in an equal time through the same sort of hole must run with three times the velocity, which will require nine times the pressure, and, consequently, the hole must be nine times as deep below the surface of the fluid, and so on.

As a proof of this, the following experiment can be tried:— Let two pipes of equal-sized bores be fixed into the side of a vessel, one pipe being four times as deep below the surface of the water in the vessel as the other is; and while the pipes run, let water be poured constantly into the vessel so as to keep it always full. Then, if a cup that holds a pint be so placed as to receive the water that spouts from the upper pipe, and at the same moment a cup that holds a quart be placed to receive the water from the lower pipe, both cups will be filled at the same time by their respective pipes.

To Construct a Water Measure.—When a stream of water flows into a cistern just as fast as it is discharged, the fluid must evidently maintain a constant level, from which the celerity is easily computed. Suppose the altitude 3 inches, the velocity of discharge would be 8 $\sqrt{\frac{1}{4}}$, or 4 feet each second; *i.e.* 240 feet a minute. The delivery would, therefore, be a cubic foot a minute, if the aperture were only the 240th part of a square foot, or three-fifths of a square inch. This opening corresponds to a circle whose diameter is ·874 parts of an inch.

Thus we have a standard measure for ascertaining readily the quantity of water delivered in a minute, &c. by any pipe or conduit. Let A B, in the annexed figure, be a cylinder of tin 4 feet long and 1 foot diameter, fitted with a float C, bearing a slender dividing rod, which passes thro' a hole in the traverse bar E stretched across the summit of the cylinder. This rod is marked 1, 2, 3, 4, at the distances of 3, 12, 27, and 48 inches, being the fourth parts of the squares of the first numbers in feet. The divisions may likewise be quartered, by beginning with the 16th part of 3, 12, 27, and 48 inches, and continuing the process by multiplying the squares of 5, , &c. as far as 16 by 3, and dividing the products again by 16. The cylinder having a circular hole with a fine edge cut in the bottom, and poised at some distance from the ground to receive the current F, the water mounts gradually in the vessel till it has gained an altitude sufficient to cause a discharge equal to the whole influx. The rod then indicates the number of cubic feet received every minute.



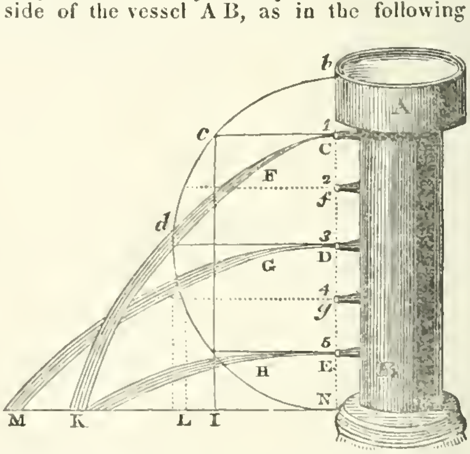
But the application of this *measurer* may be extended, by adapting to it a series of apertures which screw into the bottom of the cylinder. Let them have successively these diameters in inches, ·437—·874—1·748—and 3·496. The rod would then be square, and marked on all its four sides; the divisions on the first side corresponding to a discharge of ¼, ½, ¾, and one cubic feet; those on the next to 1, 2, 3, 4; those on the third side to 4, 8, 12, and 16; and those on the fourth side intimating a flow of 16, 32, 48, and 64 cubic feet every minute. From these data, it is easy to construct other moduli suited to particular limits. The correction required in the size of the apertures, to accommodate theory with practice, will be afterwards explained.

A cistern from which the water trickled through a small perforation at the bottom, was employed by the ancients, under the name of a *clepsydra* or *water-clock*, to measure time. In a cylinder the flow would evidently diminish, as the level of the surface was incessantly lowered. To procure an uniform descent of the water, it would be necessary to adopt the figure of a conoid of the parabolic kind, each circular section of which is proportional to the square root of the corresponding altitude. Suppose this were 24 feet, and the diameter at the top 13·28 feet, the diameters of the successive sections being always six times the fourth root of the altitude. The velocity of efflux would then be 8 $\sqrt{24}$ = 39·192 feet each second. If the water sank at the rate of a foot every hour, the width of the orifice would be to the extreme diameter, or 13·28, as 1 to 60 $\sqrt{39·192}$. This gives an aperture of ·424 parts of an inch. A conoid of such dimensions would, therefore, answer correctly as a clepsydra, the equable subsidence of a float marking the series of twenty-four hours in a natural day. This float being fastened to a thread wound about a cylindrical barrel, of a foot in circumference, would carry the index of a dial regularly round.

To shew the velocity with which water spouts out at a hole in the side of a vessel, and the horizontal distance to which it is thrown.—The horizontal distance to which a fluid will spout from a horizontal pipe in any part of the side of an upright vessel below the surface of the fluid, is equal to twice the length of a perpendicular to the side of the vessel drawn from the mouth of the pipe to a semicircle described upon the altitude of the fluid; and, therefore, the spout will be to the greatest distance possible from a pipe whose mouth is at the centre of the semicircle; because a perpendicular to its diameter (supposed parallel to the side of the vessel) drawn from that point, is the longest that can possibly be drawn from any part of the diameter to the circumference of the semicircle.

It is observed, that in every length of pipe, answering to 50 times its diameter, there is a waste of power equal to that which produces the general impulsion. With a very gentle slope, a pipe of 1·582 feet diameter, will give the flow of a single foot each second, and a pipe of one foot wide will discharge only 1·243 cubic feet of water in the same time.

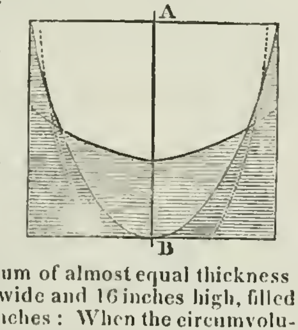
Let two pipes, as C and *g*, of equal sized bores, be fixed into the side of the vessel A B, as in the following figure,



the pipe *g* being four times as deep below the surface of the water at *b* in the vessel, as the pipe C; and whilst these pipes run, let water be constantly poured into the vessel, to keep the surface still at the same height. Then, if a cup that holds a pint be so placed as to receive the water that spouts from the pipe C, and at the same moment a cup that holds a quart be so placed as to receive the water that spouts from the pipe *g*, both cups will be filled at the same time by their respective pipes.

To illustrate the second division of this proposition, namely, that the fluid will spout to the greatest distance possible from a pipe whose mouth is at the centre of the semicircle, we have only to suppose the vessel A B (see the preceding figure) to be full of water, and the horizontal pipe D to be in the middle of its side, and the semicircle N *e d c b* described upon D as a centre, with the radius or semidiameter D N, or D *b*, the perpendicular D *d* to the diameter N D *b* is the longest that can be drawn from any part of the diameter to the circumference N *e d c b*. And if the vessel be kept full, the jet G will spout from the pipe D, to the horizontal distance N M, which is double the length of the perpendicular D *d*. If two other pipes, as C and E, be fixed into the side of the vessel at equal distances above and below the pipe D, the perpendiculars, C *c* and E *e*, from these pipes to the semicircle, will be equal; and the jets F and H spouting from them will each go to the horizontal distance N K; which is double the length of either of the equal perpendiculars C *c* or E *e*.

It is very obvious, that when an aperture is made in the side of a vessel holding any fluid, the equilibrium of hydrostatic pressure is destroyed, and this force, which was exerted equally all round the inner surface, now ceases to act at the opening, or rather it expends its action there, in projecting the uncovered portion of the fluid. The reaction, or incessant recoil sustained by the general mass, will hence be the same as the external pressure of the column of the fluid of equal altitude directed against the section of the orifice. If the vessel ave therefore a cylindrical form, and turn freely about a vertical axis, while it carries under it two horizontal branches, extending both ways, each of them perforated near the end at right angles to their plane with the axis, but in opposite sides; the machine will be driven backwards by the spouting fluid, and forced to revolve as long as the action subsists. The force thus exerted is equal to the weight of a column of the fluid having the general altitude, with the two apertures for its base. But the effect becomes augmented in this case by the length of the arms or levers to which the power is applied. This principle has been long successfully adopted in the construction of a very simple but efficient water-mill, commonly designated Barker's mill. It is capable, however, of various other useful and important applications, which remain still to be carried into execution.



The transition from these principles to those on which some maritime phenomena depend, is at this place both natural and easy. We shall, therefore, in the next branch of this article proceed to illustrate the mechanical principle of *Whirlpools*.—Thus, if a cylindrical glass vessel, as in the figure, partly filled with water, be put on a whirling table, the central depression of the liquid will increase as the circumvolution is accelerated, while its sides will rise up. It will then divide at the bottom, and spread more upwards, forming always a parabolic conoid, but with a diminishing parameter. If a thin ring were applied round the top of the cylinder, the water in its extreme celerity would cover the inside of the cylinder with a stratum of almost equal thickness Suppose a cylinder A B, 6 inches wide and 16 inches high, filled with water to the altitude of four inches: When the circumvolution is performed in ·68″, the water is depressed an inch, the central part standing at 3¾ and the sides at 4¼: but when the cylinder circulates in 24″. the cavity sinks eight inches in the bottom, and rises at the sides to the height of 8 inches. If the revolution were achieved in ·15″, the water would rise to the lips, leaving a dry circle at the bottom of the vessel of 2·49 inches in diameter. Hence, as we have said, the origin of dimples on the surface of small streams, and of whirlpools in mighty rivers and narrow seas. The effect is produced by the lateral attrition of adverse currents, which extending their influence from the neutral point or centre of equal and opposite action, gradually convert their parallel motions into a combined system of circumvolution. Suppose each current had a velocity of 9 miles an hour, or 13·2 feet each second, and the radius of the whirlpool to be 100 feet; the time of circulation would then be 47·6″, and the depression in the centre of the gulf only 2·72 feet, the parameter of the parabola being 3672 feet

When water issues through a simple circular aperture in a thin plate, it forms a contracted vein of a conical or rather tapering funnel shape, its section being reduced to very near five-eighth parts at a distance little more than half its diameter. If a tube of this figure be annexed, the quantity of discharge will come within the thirtieth part of the result of theory, as computed for the exterior aperture. But the adjutage being directed upwards, the jet will rise to fourteen-fifteenth parts of the whole height of the incumbent column.

If to this tapered spout another conical tube five times longer, and opening to the original width, be joined, the discharge of water will be augmented from 21 to 38 parts. The effect of the adjutage is now the greatest possible, the absolute flow from the interior aperture being only 40 parts, according to theory. This pipe widens at an angle of about three degrees; but when the annexed piece diverges at a greater angle, its influence becomes diminished, and appears to cease altogether at an angle of sixteen degrees. The stream has now ceased to fill up the whole of the cavity, and is consequently no longer augmented by adhesion to the sides of the spout.

The lateral action of water flowing through a pipe is evinced in a more striking manner. Let a cylinder one inch wide and three inches long be adapted to an orifice at the bottom of a cistern; and on the upper side, at the distance of half an inch from its origin, let a narrow arched glass tube be inserted and carried down to a bason of water three feet lower. When the stream is projected with a velocity of nine feet in a second, it will draw up water to the height of two feet: but if the tube be shortened within that limit, the slender column will mix with the body of the current, and soon drain the contents of the bason. When a conical tube, opening with a considerable angle of divergence, is substituted, a series of slender glass tubes inserted at different distances from the interior aperture will be found to raise the water to several heights, which diminish as the stream begins to separate from the sides of the spout.

This property of running water may, in various situations, be turned to useful account. By connecting the edge of the stream, for instance, by means of a small slanting pipe, with a collection of water at a lower level, this will be gradually drawn up and carried away in the general current. If a swift descending rivulet be made to shoot across any small pool, it will sweep the water over its opposite bank. Venturi, to whom we are chiefly indebted for these remarks, availed himself of the rapidity and lateral draught of a mill-race, to drain a marsh situate considerably below it, near the city of Modena.

The same principle is likewise the principal cause of the action of the Hungarian blowing machine, which consists of a very tall perpendicular pipe, terminating below in a close wide box. A stream of water rushes down this shaft, drawing along with it the air which enters the small holes pierced along the sides, and becomes accumulated and condensed in the chamber, whence it again issues in a powerful blast on opening a cock. The blowing and dispersion of the spray on all sides from water falls have a like origin. A body of air is involved in the broken descending current: collected in the recess or broken cavity, it exerts its elastic efforts in every direction. The adhesion of running water to the sides of its channel is also the main cause of those eddies which impede the general motion.

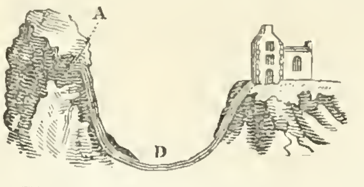
If a fluid suffers impediment while escaping at a small aperture, it encounters much greater obstruction in effecting its passage through a train of pipes, or flowing over an extended channel. This retardation, however, is quite distinct in its nature from ordinary friction. When a solid is drawn along the surface of another solid body, it is virtually made to ascend over a series of inclined planes, and consequently the impediment it meets with may be viewed as merely equal to a certain portion of its weight, independent of the rapidity or slowness of the motion. But a fluid, in its passage over a resisting surface, needs not have its whole mass either elevated or depressed. Those particles only which come in succession to touch the solid boundary, are impeded and detained. The pressure of the incumbent fluid cannot affect the other particles, which are then urged equally in every direction. The loss of impulse which a current sustains from the attrition of the sides of a pipe or of a canal, is occasioned by the incessant stoppage of the extreme particles. This consumption of force must hence be compounded of the number of particles arrested in a given time, and of their velocity, and is therefore proportional to the square of their velocity. But the retardation of the current must likewise depend on the extent of impeding influence, that is, on the length of the pipe, and on the relation which the interior surface bears to its whole capacity. But the square of the velocity, with which the stream first issues from the cistern, being proportional to the altitude of the incumbent column, a certain part only of this constant inciting force is employed in generating the initial velocity, while the rest is expended in renewing the velocity as fast as it expires, along the sides of the channel, or in maintaining through the mass a general uniform flow.

It has been ascertained by experiment, that water has its celerity diminished eight times by passing through a tube of an inch in diameter, and 204 feet long. Of sixty-four parts of compression, one part only had therefore created the motion of the fluid, while sixty-three parts are required to support it. This motion is hence renewed eight times during the passage of the water, or at the interval of 25½ feet through the whole extent. In each of these successive transits, all the central particles must be thrown towards the sides of the pipe, whence they are again drawn into the body of the stream, and there acquire new celerity. The celerity is lost and regained close to the interior surface, within a very small but limited space. Wherefore, from the fundamental principle of dynamics, the square of the velocity acquired or extinguished must be as the product of the inciting force into the limit of its action. The square of the velocity hence suffers a diminution proportioned to the extent of surface compared with the capacity of the pipe, or it is directly as the length, and inversely as the diameter. But the pressure of the water has no effect whatever in causing this reduction. Thus, resuming the same example, let the pipe of an inch wide and 204 feet long be fed by a cistern of ten inches altitude, and the quantity of discharge noted. Raise this cistern now to twenty inches, and turn up, by a soft bend, the farther extremity to the height of ten inches, and the corresponding flow will be still the same. Increase the altitude of the cistern to one hundred inches, while the remote end is bent with an elbow to the height of ninety inches, leaving still the same excess or exciting force, and the quantity of discharge will be found not to vary.

Fluids by their pressure may be conveyed over hills and valleys in bended pipes, to any height not greater than the level of the springs whence they flow. Of this fact, the ancients were altogether ignorant. The expedient of *aqueducts*, (vast rows of arches, one above another between two hills,) was therefore resorted to at an enormous expense, both of money and labour, in order to convey water across the valley beneath.—But we have already, under the word *Aqueduct*, said so much on the conduit of water, that we shall here confine ourselves chiefly to the modern method of laying down service pipes for the supply of water to cities.

The pressure of fluids affords the means of conveying them from one place to another, although considerable inequalities in the surface of the ground intervene between the places. Water, for example, may be conveyed from a reservoir across a valley, or to any distance, either by means of open canals, aqueducts, or closed pipes, provided the reservoir be situated somewhat higher than the level of the place at which it is wanted.

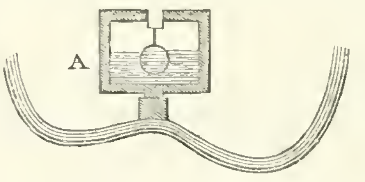
Thus, suppose there is a spring at A, on one side of the valley D, as in the annexed figure, and a house on the other, at which the water of the spring is wanted; if the house is found to be lower than the spring, the water may be conveyed to it by an iron or leaden pipe, proceeding from the spring across the valley, as in the figure.

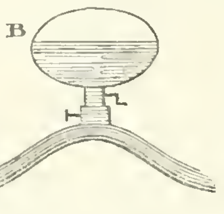


The depth of the valley must, however, be taken into consideration, in order to make the pipe of sufficient strength to resist the pressure of the water, which depends entirely on its depth. If the lowest part of the valley be considerably under the spring, the pipe must be made very strong at the lowest part, or else it will burst.

When an uninterrupted declivity cannot be obtained, it is necessary to employ pipes, which may be bent upwards or downwards at pleasure, provided that no part of them be more than thirty-two feet above the reservoir, and when the pipe is once filled, the water will continue to flow from the lower orifice; but it is best in all such cases to avoid unnecessary angles; for when the pipe rises and falls again, a portion of the air, which is always contained in water, is frequently collected in the angle, and very materially impedes the progress of the water through the pipe. When the bent part is wholly below the orifices of the pipe, this air may be discharged by various methods. The ancients used small upright pipes, called *columnaria*, rising from the convexity of the principal pipe to the level of the reservoir, and suffering the air to escape without wasting any of the water. It may, however, frequently be inconvenient or impossible to apply a pipe of this kind; but the same purpose may be answered, by fixing on the pipe a box containing a small valve, which opens downwards, and is supported by a float, so as to remain shut while the box is full of water, and to fall open when any air is collected in it. Thus A, in the following figure, is a box of this kind, with a valve, supported by a hollow ball, for letting out air from pipes, when it is below the level of the reservoir.

If the pipe were formed into a syphon, having its flexure above both orifices, it would be necessary to bend it upwards at the extremities, in order to keep it always full; but in this case the accumulation of the air would be extremely inconvenient, since it would collect so much the more copiously, as the water in the upper part of the pipe would be more free from pressure; and neither of the methods which have been mentioned would be of any use in extricating it. It has been usual in such cases to force a quantity of water violently through the pipe, in order to carry the air with it; but it might be still simpler to have a pretty large vessel of water screwed on to the pipe, which would not be filled with air for a considerable time, and which, when full, might be taken off and replenished with water. This contrivance is represented by the figure, where B is a vessel of water, screwed on for receiving the air, to be replenished with water as it becomes empty.





When the water from a reservoir is conveyed in long horizontal pipes of the same aperture, the discharges made in equal times are nearly in the inverse ratio of the square roots of the lengths.

Thus, if there be two pipes of the same aperture, one of which is 49 and the other 36 feet long, the discharge from the former will be to that from the latter, as the square root of 49 to the square root of 36, or as 7 to 6; therefore, the quantity discharged from the shorter pipe will be $\frac{6}{7}$ of that discharged from the longer one. It is here supposed, that the pipes to which this rule is applied, are not very unequal in length; and even then the rule only affords an approximation not deduced from principle, but derived immediately from experiment. Bossut has given a table of the actual discharges of water pipes, as far as the length of 2340 toises, or 14950 English feet, but it is too extensive to be inserted here.

If the quantity of water discharged by a pipe of a given length, be known by experiment, we may find, by the foregoing proposition, the quantity discharged by a pipe of any other length. The diminution of velocity being greatest when the head of water is small, we may conceive the head of water to be reduced to such a degree, that the velocity with which the water enters the pipe is not sufficiently powerful to overcome the resistance arising from the friction upon the pipe, and the mutual cohesion of the particles of water. In order to examine this point experimentally, M. Bossut employed a head of water only 16 lines, from which the water flowed into two pipes, whose length were a hundred and eighty feet. In this case, the water was discharged in the form of a narrow fillet, and the drops succeeded each other almost as if they were insulated bodies. Hence it follows, that in order to have a perceptible and continuous discharge from pipes, there should be a head of water of about 20 lines in 180 feet. If the current of water, however, be very large, such a great declivity as this will not be necessary.

Pipes are usually made of wood, of lead, or of cast iron: but commonly of lead; and of late tinned copper has been employed with considerable advantage. A pipe of lead will bear the pressure of a column of water 100 feet high, if its thickness be one-hundredth of its diameter, or even less than this; but when any alternation of motion is produced, a much stronger pipe is required; and it is usual to make leaden pipes of all kinds far thicker than in the above proportion.

We have already illustrated the velocity and discharge of water through pipes and conduits, and noticed the retardation to which the fluid is exposed. Now, if we conceive a rectangular channel to have a section equal to the circle of the pipe, while its bottom and sides are equal to the circumference, the retardation of the current would be exactly the same. Hence, the fourth part of the diameter will be equal to the quotient of the section, by the compound measure of its bottom and sides, which is called the mean hydraulic depth; and hence much less obstruction is encountered along an open course, than within a close pipe, or about three times the square root of the depth.

The motion of a fluid is further obstructed by any violent change of celerity or direction; whether the channel be contracted or enlarged, the change is unavoidably attended by a proportional loss of impulsion. Any sharp flexure of the pipe or conduit will occasion a still greater waste of the inciting force. The diminution of the square of the velocity is expressed by the product of that square into the square of the sine of the angle of deflexion, divided by the constant number 270. With a deflexion of 30 degrees, the velocity would therefore lose only the 2160th part; but if the tube branched off at right angles, the retardation would amount to the 540th part. Every contraction or enlargement of the pipes requiring a corresponding change in the celerity of the water, must likewise create an expense of force, though this effect could scarcely be reduced to calculation.

Water is subject in its motion through pipes to another impediment, owing to the air which constantly separates from it and collects in all the upper sinuosities of the train, as already noticed. This accumulation is most copious whenever the supply of water happens to be insufficient to fill the whole extent of cavity. To remedy the defect, boxes of cast iron are fixed above the principal incurvations of the pipe, to receive the compressed air, as represented in the last figure, and by the operation of a valve or of a cock, gradually to discharge it, without allowing any of the water to escape. Of such air-vessels, with a cylindrical form, four feet high and eighteen inches wide, fourteen have been made, for the pipes which supply the city of Edinburgh with water. These being screwed at the summit of each declivity, are opened, every two or three days, by the surveyor of the works.

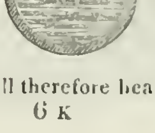
The present supply of Edinburgh, says Leslie, is brought by two trains of cast iron pipes; one from Green Craig to the Castle Hill, 26,930 feet long, and 7 inches in diameter, under a head pressure of 404 feet; the other from Comiston to Heriot's reservoir, 13,520 feet long, and 5 inches wide, under a load of 88 feet. The former, when fully charged, is found to deliver 46, and the latter only 10 cubic feet, every minute, making together 56 feet, which furnishes a supply of 80,640 cubic feet in the space of twenty-four hours. This amounts to scarcely three-fifth parts of the quantity assigned by the formula. The deficiency must be attributed wholly to the imperfect execution of those pipes, their uneven interior surface, and their frequent abrupt and sudden bendings.

The waterworks now designed for the complete supply of Edinburgh, are conducted in a much finer style, and at vast expense. The several pieces of pipe are nicely fitted together by spigot and faucet, all the accidental prominences over the inside being carefully removed by chiseling. The pipes exhibit no visible incurvation, and they generally are laid with a gentle uniform slope, the ground on which they rest being lowered in some places and raised in others. From the Crawley Spring to Straiton March Fence, the distance is 18,300 feet, with a fall of 65 feet; and, in this line, the pipes vary from 20 to 18 inches, in diameter. The next train has a diameter of only 15 inches, but runs, with a fall of 286 feet, through an extent of 27,900 feet, being conducted by a tunnel of 360 fathoms length through Heriot's Ridge, and by another of 290 fathoms through the Castle Hill, till it reaches the level of Prince's-street. This elaborate system of pipes delivers nearly the measure of water indicated by the formula.

It has been computed, that the quantity of rain which falls annually over any city, if carefully collected and deposited to purify in cisterns, would be sufficient for the supply of the inhabitants, at least in all the essential domestic and culinary purposes. Venice has abundance of fine soft water procured in this way; and the store seldom fails, except in dry seasons, when it is recruited from the river Brenta. The roof of a lofty house in Paris, containing at an average 25 lodgers, might deliver annually 1800 cubic feet of rain water, which would furnish each individual daily the fifth part of a cubic foot, or about thirteen pounds avoirdupois,—rather a scantity provision, to be sure, according to our modern ideas of comfort; yet Prony reckons ten *litres*, or the thousandth part of his modulus, as a sufficient supply, amounting only to about twenty-two pounds. See the word AQUEDUCT pp. 51—53.

Since, from a pipe of the same diameter, the discharge in every case depends on the relation of the altitude of the source to the length of track, a lower elevation may frequently be preferred in conjunction with a shorter train. The diminished obstruction, in such instances, compensates for the inferior pressure. From any point of an inclined plane, the pipe would convey exactly an equal body of water. In the same train, the quantity of discharge being as $d^{\frac{5}{2}}$, must increase in a faster ratio than the mere section of the pipe. Hence the manifest advantage of employing large pipes. For the same reason, aqueducts or open conduits are in many situations to be preferred. When these convey large streams of water, the attrition of the sides and bottom is comparatively small, and they require very little descent. Such durable structures are common in the south of Europe, and often display much architectural symmetry in their extended and imposing ranges of arcades.

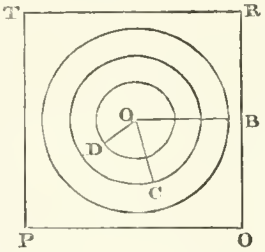
Circular Basins and Conduit Pipes.—These basins and pipes bear a lateral pressure proportioned to the altitude of the column; but in consequence of the curvature, this pressure will occasion likewise a longitudinal strain or distention. And the lateral pressure of the water against each ring of the cylinder, as in the annexed figure, B A C, produces the same effect as a longitudinal force applied to it equal to the weight of a prism resting on a base which has the breadth of that ring, with the radius O B for its thickness. Hence, the strength of the cylinder is in the compound ratio of the altitude of the water, and of its own radius or diameter. Similar pipes will therefore bear equal pressures, their thickness being pro-



portioned to the diameter. For example, a pipe 1 foot diameter, and half an inch thick, will resist the thrust of the same altitude of water as a pipe of the same materials 2 feet wide and 1 inch thick. Lead, however, has only one-tenth of the tenacity of cast iron, and therefore a pipe of that soft metal will, in similar circumstances, require to have ten times greater thickness in proportion to its diameter, than one of iron. Such is the case with a pipe of elm, while one of freestone would require to have its thickness doubled. A pipe of cast iron, 15 inches diameter, and ¾ inch thick, will bear a pressure equal to 600 feet in altitude; and a pipe of the same diameter, but 1¼ inch thick, will bear a pressure or strain of 1000 feet, the cohesion of cast iron being 6000, or in its greatest reduced state 2600 lbs.

A very proper way to try the strength of such cast iron pipes is, by means of a large forcing pump, and every pipe of the above dimensions that would not bear the pressure of a column of water respectively of the altitudes of 400 and 800 feet, ought to be rejected as betraying flaws, and being unsafe.

A pipe of lead 4½ diameter, and ⅗ of an inch thick, sustained only the thrust of 172 feet in height of water; a pipe of oak 15 inch bore diameter, and 2 inches thick, will sustain a column of water only 179 feet high, the cohesion of oak being 2316 lbs. The cohesion of Portland stone is only 857 lbs. and therefore a pipe 1 foot diameter, and 1½ inch thick of that material, will sustain a pressure of only 62 feet; hence the failure from fracture and chipping, of those handsome stone pipes so ingeniously cut out of blocks of freestone in a series of cores, by the application of a circular saw, as in this figure, where O B represents the largest or first cut, O C the bore of the second cut, and O D the third pipe squared out of the block P O R T.



The same principles regulate the strength of a circular basin confining water. The perpendicular pressure against the wall depends indeed merely on the altitude of the fluid, without being affected by the volume; but the longitudinal effort of the thrust, or its tendency to open the joints of the masonry, is measured by the radius of the circle. To resist that action, in very wide basins, the range or course of stones, along the inside of the wall, must be proportionally thicker. On the other hand, if any opposing surface present some convexity to the pressure of water, the resulting longitudinal strain will now be exerted in closing the joints, and consolidating the building. Such reversed incurvation is hence generally adopted in the construction of dams, the bend inwards of the arc being about the eightieth part of the length of its chord, while the exterior boundary is made rectilineal.

The various Hydraulic Machines, as the *Syphon*, *Archimedes' Screw*, the *Tympanum*, the *Persian Wheel*, *Chain and Spiral Pumps*, the *Hungarian Machine*, *Fire Engine*, *Hydraulic Ram*, the *Danaide*, *&c.* are all described in various parts of this Dictionary under their respective words.

HYDROCELE, in Surgery, any hernia arising from water, but is particularly used for such a one of the scrotum.

HYDRODYNAMICS, treat of the powers, forces, and velocities, of fluids in motion.

HYDROGEN. It had been long known to the chemists, that a vapour of air was disengaged during the solution of certain metals in muriatic or dilute sulphuric acid, that it burnt at the mouth of the phial, and if mixed with atmospheric air, exploded when kindled by a match. This substance forming water when combined with oxygen, and being therefore the radical of that compound, the name hydrogen was given to it at the formation of the new nomenclature. It is always obtained from the decomposition of water, as it cannot, from other substances in which it exists, be easily disengaged in perfect purity. Some substance is made to act on water, which exerts an attraction to the oxygen, without combining with the hydrogen, when of course the hydrogen is disengaged, and passes into the elastic form. If a coil of iron wire, or a quantity of iron filings, be put into an iron or coated glass, or earthen tube which is placed across a small furnace, and surrounded with burning fuel, so as to be brought to a red heat, on distilling water from a retort connected with it, the vapour, in passing over the surface of the ignited iron, is decomposed, the iron attracts its oxygen, and hydrogen gas issues from the extremity of the tube.

This process is a troublesome one, and by the agency of an acid, water is decomposed as rapidly by iron or zinc, at a natural temperature. Zinc affords the hydrogen in the greatest purity. One part of it, in small pieces, is put into a retort, or a bottle with a bent tube adapted to it; two parts of sulphuric acid, previously diluted with five times its weight of water, are poured upon it, an effervescence is immediately excited, hydrogen gas escapes, and is to be collected in jars filled with water. These co-operating, produce a ternary combination, while the hydrogen gas is disengaged. Hydrogen gas is permanently elastic. When collected over water, it is observed to have a peculiar smell, slightly fetid. It is the lightest of the gases, and indeed the lightest substance whose gravity can be ascertained by weighing. Its specific gravity varies considerably, according to its state with regard to humidity. When it has been transmitted through water, it is about ten times lighter than atmospheric air; when it has been received over quicksilver, and exposed to any substance which attracts water strongly, it is near 13 times lighter. It is from this levity that it was applied with success to the construction of balloons.

After it was first discovered that oxygen and hydrogen gases by combustion produced water, the French chemists, to verify the experiment, made an immense reservoir of oxygen gas, and another of hydrogen gas, and caused a small stream from each to meet and inflame, and so to continue for several days. The result was a large quantity of excellent water.

The chemical property by which hydrogen gas is most eminently distinguished, is its great inflammability. When an ignited body is approached to it in contact with the atmosphere, it is immediately kindled, and continues to burn while the air is admitted; if previously mixed with atmospheric air, and a burning body approached to the mixture, or an electric spark sent through it, it instantly inflames with detonation; and when it has been mixed with oxygen gas, the detonation is more violent. Though hydrogen gas be inflammable, it is incapable of supporting the combustion of other inflammables. This gas is incapable of supporting animal life by respiration; an animal immersed in it is soon killed. At the same time, it does not appear to be so positively deleterious as the other noxious gases. Rosier, even after expelling the air from the lungs, breathed hydrogen gas for several respirations. It is not noxious to vegetable life; at the same time, it appears to contribute little to the nourishment of plants.

Hydrogen gas is so sparingly soluble in water, that when agitated with it, it suffers no perceptible diminution of volume. The affinities of hydrogen seem principally exerted towards inflammable bodies. Hydrogen gas is found collected often in mines, derived probably from the decomposition of water by metals; it is known to the miners by the name of fire damp, and is often the cause of accidents from exploding on the approach of an ignited body. It is also extricated from stagnant water, and from marshy situations, from the slow decomposition of vegetable and animal substances. From its levity it has been supposed that the quantity of it thus produced at the surface of the earth, will rise through the atmosphere and occupy the higher regions; and on its presence, some of the phenomena of meteorology, particularly the sudden appearance of some fiery meteors, have been supposed to depend.

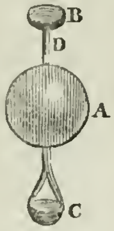
HYDROGRAPHY, the art of measuring and describing the sea, rivers, lakes, and canals.

HYDROMETER, an instrument for measuring the density, gravity, &c. of water and other liquids; that which is designed simply for ascertaining the specific gravity of different waters, is more commonly called an Areometer, or waterpoise; the term hydrometer being more commonly employed to denote an instrument for measuring the specific gravity of spirits, though it is sometimes used indifferently for either.

Mr. Clarke constructed an hydrometer, shewing whether any spirits be proof, or above or below proof, and in what degree. This instrument was made of a ball of copper, (because ivory imbibes spirituous liquors, and glass is apt to break,) to which is soldered a brass wire about a quarter of an inch thick; upon this wire is marked the point to which it exactly sinks in proof spirits; as also two other marks, one above and one below the former, exactly answerable to one tenth above proof and one tenth below proof. There are also a number of small weights made to add to it, so as to answer to the other degrees of strength besides those above, and for determining the specific gravity of different fluids.

Dr. Desaguliers' hydrometer determines the specific gravities of different waters to such a degree of nicety, that it shews when one kind of water is but the 40,000 part heavier than another. It consists of a hollow ball of about three inches in diameter, charged with shot to a proper degree, and having fixed in it a long and very slender wire, of only the 40th part of an inch in diameter, and divided into tenths of inches, each tenth answering to the 40,000th as above.

Nicholson made an improvement by which the hydrometer is adapted to the general purpose of finding the specific gravity both of solids and fluids.



A is a hollow ball of copper, B a dish affixed to the ball by a short slender stem D; C is another affixed to the opposite side of the ball by a kind of stirrup. In the instrument actually made, the stem D is of hardened steel $\frac{1}{40}$ of an inch in diameter, and the dish C is so heavy as in all cases to keep the stem vertical when the instrument is made to float in any liquid. The parts are so adjusted, that the addition of 1000 grains in the upper dish B, will just sink it in distilled water, at the temperature of 60° of Fahrenheit's thermometer, so far that the surface shall intersect the middle of the stem D. Let it now be required to find the specific gravity of any fluid. Immerse the instrument in it, and by placing weights in the dish B cause it to float, so that the middle of its stem D shall be cut by the surface of the fluid. Then, as the known weight of the instrument, added to 1000 grains, is to the same known weight added to the weight used in producing the last equilibrium, so is the weight of a quantity of distilled water displaced by the floating instrument, to the weight of an equal bulk of the fluid under examination. And these weights are in the direct ratio of the specific gravities.

Again, let it be required to find the specific gravity of a solid body, whose weight is less than 1000 grains. Place the instrument in distilled water, and put the body to the dish B. Make the adjustment of sinking the instrument in the middle of the stem, by adding weight in the same dish. Subtract those weights from 1000 grains, and the remainder will be the weight of the body. Place now the body in the lower dish C, and add more weight in the upper dish B, till the adjustment is again obtained. The weight last added will be the loss the solids sustain by immersion, and is the weight of an equal bulk of water. Consequently the specific gravity of the solid is to that of water, as the weight of the body to the loss occasioned by the immersion. This instrument was found to be sufficiently accurate to give weights true to less than one-twentieth of a grain.

HYDROPHILUS, in Natural History, a genus of insects of the order of coleoptera, that inhabit ponds and stagnant waters, where they swim with much dexterity; they fly abroad by night in search of other waters.

HYDROPHOBIA, an aversion or dread of water; a terrible symptom of the rabies canina.

HYDROSCOPE, an instrument anciently used for the measuring of time. The hydroscope was a kind of water-clock, consisting of a graduated cylindrical tube, conical at the bottom, or marked out with divisions, to which the top of the water becoming successively contiguous as it trickled out of the vortex of the cone, pointed out the hour.

HYDROSTATICS, is the science which treats of the mechanical properties of fluids. Strictly speaking, the weight and equilibrium of fluids at rest, are the objects of this science. When the equilibrium is destroyed, motion ensues; and the science which considers the laws of fluids in motion, is hydraulics.

A fluid is a body whose parts yield to any impression, and in yielding, are easily moved against each other. Fluids are of two kinds; non-elastic and incompressible fluids, such as water, oil, mercury, &c.: and elastic and compressible fluids, such as air of different sorts.

Modern philosophers suppose that a certain portion of heat, combined in some way or other with bodies, occasions fluidity, and that the relative portions of heat contained in fluids and solids, is the cause of the difference between them. And it is from the imperfect cohesion of fluids, that, when in small quantities, they arrange themselves in a spherical manner, and form drops.

A portion of fluid gravitates in another when surrounded by a larger portion, in the same way as if it were in air. But fluids have this remarkable property also, that they press not only in common with solids perpendicularly, but also upwards, sideways, and in every direction equally. Take a glass tube open at both ends, and stopping one end with your finger, immerge the other in water. The water will be prevented from rising far in the tube by the air which is contained in it; but if you take away your finger from the upper end, the air within the tube will be suffered to escape, and the water will rise in the tube to the same level as it is in the vessel, being pressed upwards by the surrounding water. The same effect will take place, if you incline the tube in any direction; or if you make use of tubes bent in any manner; still you will find that the water within them will rise to the same height as in the external vessel. From this property it is, that if you bore a hole in the side of a vessel filled with water, the fluid will spout out.

A fluid presses in proportion to its perpendicular height, and the base of the vessel containing it, without any regard to the quantity: for as fluids press equally in every direction, the horizontal bottom of a vessel sustains exactly the pressure of a column of fluid, whose base is the area of the bottom of the vessel, and whose perpendicular height is equal to the depth of the fluid.

The pressure exerted against the bottom of a vessel is in nowise augmented by its spreading shape. Thus, in the vessel A B, fig. 1, the bottom B C sustains a pressure equal to the column whose base is C B, and height C E, and not as the whole quantity of fluid contained in the vessel. Also in the vessel F G, fig. 2, the bottom G H, sustains a pressure equal to what it would be if the vessel were as wide at the top as it is at the bottom.

Fig. 1.

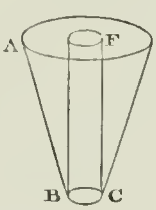
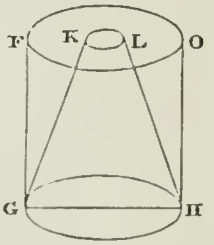
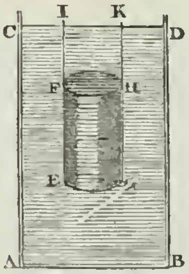


Fig. 2.



This very singular and important conclusion, that the pressure of a liquid upon the bottom of any vessel depends merely on its altitude and the surface of its base, might be derived from simpler but indirect considerations. Suppose the portion of a liquid, which encircles the vertical cylinder F C B, (as in the annexed figure,) to be frozen or converted into a solid substance, but without changing its density; the pressure of this congealed mass would evidently continue the same as before, and therefore the bottom has only to sustain the weight of the cylindrical column which rests immediately upon it. If the lateral ice were again melted, it would assume its horizontal thrust, which could not alter the vertical pressure of the liquid. In like manner, if F G M were a cylinder of liquid resting upon a circular base, and the portions F G K, L H O about the sides were rendered solid or congealed, without alteration of density, the remaining portion G K L M will evidently exert

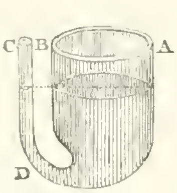


the same pressure as before; and the incurved sides K G, L H produce an effect analogous to the load of the supposed frozen masses F G K, L H O.

Suppose any interior portion of a liquid to become solid; it would evidently remain in the same state of indifference or equilibrium as before. It must therefore be borne up by the vertical pressure of the fluid with a force just equal to its weight, or the weight of the liquid whose place it occupies. Conceive this congealed mass to have its gravity augmented or diminished; it must evidently be pulled downwards or upwards by the difference between this force and the weight of an equal bulk of the liquid. Substitute any solid body instead of this block of ice, and *the loss of weight it suffers by the immersion will be equal to that of the volume of fluid which it displaces.* This fundamental property, first detected by the genius of Archimedes, may be demonstrated by a stricter process of reasoning. Let a cylindrical body F E G H, be plunged vertically in a vessel C A B D, filled with water or any other liquid; the lateral pressure, acting equally around the axis, will evidently produce a complete balance of efforts. But the cylinder will be pushed upwards by a column of fluid having I E for its altitude, and the circle E G for its base, and pressed downwards again by the circular column I F H K. The solid is, therefore, buoyed up by the excess of the former force above the latter, or by the weight of an equal cylinder F E G H of the liquid. In fact, the solid body loses by immersion, just as much weight as that of an equal volume of the surrounding fluid; and, on this principle, is founded the method of ascertaining the density of a body, or the relation of its weight to its bulk, which, in reference to some common standard, is termed its *specific gravity*. Water, at its state of greatest contraction, is preferred as the most convenient unit of comparison, the density of other bodies being reckoned in decimal parts. The *Hydrostatic Balance* is generally used for this purpose. The substance to be examined may be either liquid or solid. The specific gravity of liquids is easily determined, by means of a ball or pear-shaped lump of glass or crystal, either partly hollow or loaded. This poise, suspended by a hair or fine thread, is weighed *in vacuo* or in air, then in pure water, and next in the particular liquid; the loss of weight which it suffers in water is to its loss in the fluid under trial, as unit to the specific gravity of this fluid. The calculation is sometimes carried to five places of decimals; though it is seldom safe or expedient to push them beyond three figures. If the lump of glass were ground to such a size as to lose exactly a thousand or ten thousand grains in distilled water, no computation would be required, its loss of weight, by immersion, indicating at once the specific gravity of the liquid.

This leads to what is called the *Hydrostatical Paradox*, which is, that a small quantity of fluid may be made to counterpoise the greatest quantity.

Thus, if to a wide vessel A B, you attach a tube C D communicating with the vessel, and pour water into either of them, it will always stand at the same height in both, consequently there is an equilibrium between them. And of whatever shape the vessels are, the effect will be the same. This fact is confirmed by a variety of striking experiments, and forms an essential consideration in all water works. But the principle extends its influence to masonry; for if the smallest quantity of water should lodge to a considerable height in the gravel, sand, or loose earth, close behind a wall or solid embankment, it would exert a lateral pressure sufficient to push the solid materials from their base. Hence, a sudden shower, great devastation, the thinnest vein of water collected in a perpendicular crevice, will split the hardest rock, and hurl the fragments to its base. Thus hydrostatic pressure is the silent, but irresistible agent, which nature employs in the gradual demolition of mountains.



A *Perpetual Syphon*, which possesses the faculty of making liquids pass from one vessel to another, even after the vessels are empty and the action ceases, has two unequal arms; after entirely plunging it into any liquid, in order that it may be filled, and taking care that both orifices are constantly immersed, each extremity of the syphon is introduced into a small vase or reservoir, filled with the same liquid, in which is plunged each end. Thus the immersion of the two ends is constant; and the entrance of the air and escape of the liquid are equally prevented; the syphon, always full, is in constant action, by only immersing one of its branches, without the aid of air, opening or shotting cocks, &c. What is remarkable in this invention, is the fact, that as soon as one vessel is empty it is filled again from the other; and so on continually.

The Hydrostatic Bellows.—This instrument is perhaps the best yet invented for demonstrating the upward pressure of fluids, and it is fully illustrated under the word Bellows, p. 104.

The *Hydrostatic Balance* has been already illustrated; and *Specific Gravities* were handled under the word Gravity.

Solid Bodies Floating on Fluids.—A solid floating on a fluid specifically heavier than itself, will be in equilibrio, or will rest, when it has sunk so far that the weight of the fluid displaced is equal to the weight of the whole solid, and when the centres of gravity of the whole solid, and of the part immersed, are in the same vertical line.

Hence, every solid, specifically lighter than a fluid which has an axis that divides it into two similar and equal parts, when placed in a fluid with its axis vertical, may sink to a position in which it will remain in equilibrio; that is, without turning either to the one side or the other.

In such bodies there are always two opposite positions of equilibrium; but there is only one of them in which the body can float permanently.

When the equilibrium of a floating body is disturbed, or when the centres of gravity of the whole, and the part immersed, are not in the same vertical line, the body will revolve on its axis, till it come into the position where these two points are in the same vertical line.

There are some bodies that in every position these two points are in the same vertical line. A homogeneous sphere, or globe, is a body of this kind; and so is a cylinder floating with its axis horizontal. These bodies have no tendency to maintain one position more than another; and their equilibrium, or floating position, is called the ***equilibrium of indifference.***

Some floating bodies, when their equilibrium is disturbed, return to their steady position after a few oscillations backwards and forwards. Others, when ever so little disturbed, do not resume their former position, but turn on their centres of gravity, till they come into another position, when they are again in equilibrio. In the first case the equilibrium is said to be stable, in the latter case to be unstable, and then the body is said to *overset*.

When a floating body is made to revolve from the position of equilibrium, if the line of support (that is, the vertical line passing through the centre of gravity of the immersed part) move so as to be on the same side of the line of pressure (or the vertical passing through the centre of gravity of the whole) with the depressed part, the equilibrium is *stable*, and the body will resume its former position. But if the line of support is on the same side of the line of pressure with the elevated part, the equilibrium is *unstable*, and the body will overset.*

When a floating body revolves about a given axis, the positions of equilibrium through which it passes are alternately those of stability and instability: for between a state in which a body has a tendency to remain, and another in which it has also a tendency to remain, as these tendencies are opposite to one another, there must be an intermediate position in which the tendency to remain is equal to nothing, or the body will revolve on its axis.

If the form and size of a body, floating in a fluid, be known, and its altitude above the surface, and the specific gravity of the fluid be also known, its stability may be calculated.

Having given the general principles of this branch of science, we may explain in more popular speech a few of the leading characteristics in the doctrine of fluids. First then, every substance appears composed of an assemblage of atoms, connected together by a system of mutual attraction and repulsion; in solids, the atoms resist every change of figure; in fluids, they yield to the slightest external pressure, because their particles are loosely connected. A solid reduced to a plane easily folds up in one direction; if reduced to filaments it will bend every way, without breaking; crumbled to dust or powder, the aggregate particles submit to any external impression, and evince no sympathy of concatenation.

---

* The centre of gravity of any body is that point upon which the body, when acted upon only by the force of gravity, will balance itself in all positions. This will be more fully explained when we come to treat of Mechanics.

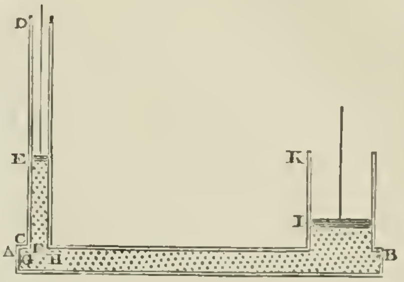
A solid body, subjected to a compressing force, undergoes a proportional contraction, but recovers its volume after this contraction is withdrawn. But if the compression be urged beyond a certain limit, the substance will be crushed under the load, and will suffer a complete dissolution. A fluid, however, enclosed in the chamber of a very strong metallic vessel, is found to be capable of withstanding the greatest pressure we can command, though its contractions are comparatively more extensive; and it always returns with unimpaired vigour to its former condition, the moment such external force has ceased to act. The constitution of a fluid remains unaltered under the most enormous loads, and its several portions, at all times, separate and reunite with extreme facility. Whether the fluid has a liquid or assumes a gaseous form, it can equally bear any compression, the corresponding contraction of the latter being only much greater than that of the former.

If the minutest subdivision of a solid contributes nothing to fluidity, neither will any supposed smoothness or globular shape of the particles confer that character. Exact spherules might procure lubricity on a plane, but, among one another, they will become implanted, and affect certain configurations, as manifested in the common piling of shot. The absolute contact of the particles is besides inadmissible, since all bodies whatever seem to be capable of indefinite condensation.

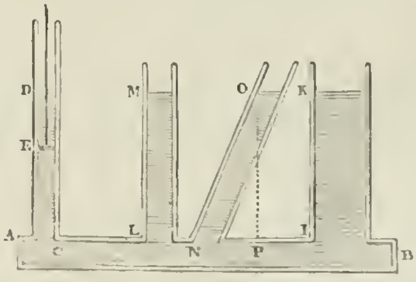
But fluidity occurs in very different degrees. Any disturbing impression is more quickly obeyed by one liquid than by another; by water, for instance, than by oil or treacle. All the possible shades of softness, in fact, might often be traced from a solid to a fluid substance. The application of heat generally promotes fluidity. Thus, honey in winter is a candied or friable solid; in the spring it melts down; but as the summer advances, it gradually loses its viscidity, and flows more freely. Oil seems affected in the same way, and hence the practice in Italy of depositing it in casks for exportation during the winter season, when it is thickest and least penetrating. But water itself, and other liquids, not excepting mercury, have their fluidity likewise augmented by heat, as evinced in their quickened flow through capillary tubes.

If an angular bit of glass be held in the flame of a blowpipe, it will become gradually rounded, as the heat penetrates and softens the mass. In like manner, a fragment of scaling-wax loses its rough exterior, and assumes a regular curved surface, on approaching it to the fire. But the centre of curvature is the point to which the combined attractions of the outer range of particles must be directed. Since this point retires, therefore, from the surface with the progress of softness to fluidity, the mutual connexion of the integrant molecules must be exerted over a much greater extent in fluids than in solid substances. This inference appears to afford likewise an explanation of the facility of their internal motion, so conspicuous in liquids. When the sphere of activity is confined, as in solids, to a very narrow spot, a few particles only are connected by their sympathetic tendencies. Any internal dislocation will in this case require the approximation of certain particles and the recession of others, which must hence occasion the exercise of corresponding repulsive and attractive forces. But these forces, being directed to a small number of centres, will constitute a very unequal group, incapable of gaining a smooth and graduated equilibrium. Every change of inclination would produce a violent effort to attain a new position of repose. On the other hand, when the sphere of activity embraces a multitude of particles, as in the composition of fluids, the slightest mutual derangement will be sufficient to accommodate every variation of external impression. The most minute deviation of each particle would, by such prodigious repetition, amount to any required change of direction. In their dislocations, the particles are almost unconstrained, and need scarcely approach or recede; the repulsive and attractive forces evolved become therefore extremely small, and by their multitude produce in every position nearly a perfect counterbalance. A fluid is hence fitted to obey any impression with the utmost facility.

But whatever may be the system of forces that connects the fluid atoms, the properties of the compound are deducible, from the absolute facility with which those ultimate particles receive and transmit external impressions. Suppose a fluid, either gaseous or liquid, to be enclosed in a very broad and extremely shallow cylinder of glass or metal A B (as in the annexed figure,) at the top of which is inserted a tall narrow tube C D of the same material, and having a plug or piston E nicely fitted into it. On pushing down this piston, the fluid particles under it will at first give way, and approach closer to each other. They will, in consequence, display a repulsive force proportional to this mutual approximation. Now, it is easily seen that points or atoms can never be ranged through space in perfect straight lines; and, therefore, the pressure will not be confined to the vertical column, but will insensibly diverge in all directions. The particles at F will repel obliquely those at G or at H, and these again will communicate their oblique impression to other adjacent particles. The whole stratum of fluid, from the orifice C to A and B, must hence continue to recede from the piston, and contract its volume, till the integrant particles have all attained the same mutual distance, and exert the corresponding repulsive energy. A uniform condensation must thus be diffused through the mass, before an equilibrium can take place. This condition obtains equally in liquids and in gaseous fluids, only the contraction produced from a compressing force, which is so visible in the former can seldom be distinguished by ordinary perception in the latter. But a very minute alteration of the volume of a liquid evolves as much force, as an extensive change in the mass of a gaseous fluid.



The pressure exerted by the piston E at the orifice C is therefore equally diffused through the whole of the fluid A B, every particle of which acquires the same intensity of repulsion. Each point on the surface of the vessel must hence sustain an equal effort. If a wide cylinder I K, fitted also with a piston, were inserted at I, the compression resisted by it would be proportional to the space of action or the circle of the orifice. On a supposition that the surface of the piston I were ten times greater than that of E, it would likewise support a load ten times greater than the pressure applied at E or C.



Let the piston I be now removed, while the piston E is conceived to act as before. The liquid must evidently rise in the cylinder I K, (as in the annexed figure,) till its weight become equal to the pressure exerted at the orifice I. In like manner, if another cylinder L M were inserted, the liquid would rise, till its weight was equal to the pressure at L. But the pressures at I and L being proportional to those orifices, or the circular sections of the cylinders I K and L M, the altitudes I K and L M of the columns themselves must be equal. If a cylinder N O were inserted obliquely, the liquid would still rise to the same level; for in this case, the column being partly sustained by the under side, its weight would, from the property of the inclined plane, be to its pressure at N, as the length O N to the perpendicular O P.

Let the piston E itself be now withdrawn, and the liquid will mount in the cylinder C D, till its weight becomes equal to the pressure applied at C, and consequently will attain the same altitude as in the other communicating cylinders. Suppose the cylinders to be enlarged and brought nearer to each other, still the same level will be maintained among them. Conceive they were even united, so as to compose a single cylindrical vessel, and the contained liquid would always assume a level surface. Such is the distinguishing character of fluids.

It hence follows, that the condensation accumulated at any point of an open liquid mass, and therefore the actual pressure exerted there, is proportional to the altitude of the incumbent column of a supposed vertical tube, or the depth of the point below the surface of the fluid. The pressure of water against the perpendicular sides of any cistern must thus increase regularly from the top to the bottom. In a cubical vessel, the pressure borne by each side would be just half the weight supported at the bottom, and consequently the aggregate pressure sustained by all the four sides would be double this weight.

That the pressure of a fluid is exerted equally every way in proportion to its depth, may be confirmed by various experiments. Thus, having fastened a long narrow glass tube to the neck of a thin bladder, fill this with water till it stand perhaps an inch above, and plunge the whole in a tall jar of water; the liquid will be seen to rise in the tube, and maintain the same altitude, exactly in proportion as the bladder descends. Again, if a high gass tube, spreading below into a wide funnel mouth, to which a loaded plate of brass has been ground and closely fitted, were let down and held in a body of water, at the depth where a cylindrical column of fluid, incumbent upon its broad bace, has a weight equal to that of the plate, this would remain supported. But if a hole were pierced in the side of the tube, admitting a small portion of the water to fill up the funnel, its load would instantly be precipitated to the bottom. On the other hand, if the tube had its funnel mouth turned upwards, and fitted with a thin brass plate surmounted by a very thick cylinder of cork; the buoyancy of this cover would be overcome at a certain depth below the surface of the water. But, on letting water into the funnel, the pressure now exerted under the plate would immediately float it up.

The fundamental principle, that a fluid compressed in a close shallow vessel exerts the same effort upon every equal portion of the confining surface, was first distinctly stated by the famous Pascal, who even proposed it as a new mechanical power of great efficacy and ready application. If the piston I (p. 497,) were, for instance, an hundred times larger than the piston E, the force of one man pushing down the former would be sufficient to withstand the action of an hundred men upon the latter. Nor did another feature of resemblance escape this acute philosopher, that, as in all other mechanical combinations, what is here gained in power is lost in celerity, or, in other words, that the height to which a load is raised is still inversely as the purchase. Thus, while the piston E descends through one inch, the piston I ascends only the hundredth part of an inch. This consideration is essentially the same as the principle of *virtual velocities*, which affords another demonstration of the equality of pressure diffused through a fluid. For, if one pound depress the piston E one inch, the piston I will lift an hundred pounds over the hundredth part of an inch, the momentum of the weight at E being still equal to the opposite momentum of the load incumbent at I. The pressure exerted by the fluid upon every point of the surface of the shallow vessel is hence the same.

The project originally started by Pascal, of applying this capital property of fluids to the construction of a powerful mechanical engine, has been reduced to convenient practice in our own time. The progress of the arts has now begun to realize all the delicacy of theory. Watt employed, to a certain extent, the soft compression of air, as the chief agent of his coining engine; while Bramah has successfully availed himself of the constrained energy of water in the construction of his hydraulic press.

HYDROSULPHURET, in Chemistry, the combination of sulphuretted hydrogen with an alkaline or earthy base. They are soluble in water, and crystallizable; the solution is colourless, while the action of the air is excluded; but when that is admitted, a yellow colour is soon acquired.

HYGROMETER, a machine or instrument to measure the degrees of dryness or moisture of the atmosphere.

There are divers sorts of hygrometers; for whatever body either swells or shrinks by dryness or moisture, is capable of being formed into an hygrometer. Such are woods of most kinds, particularly ash, deal, poplar, &c. Such also is catgut, the beard of a wild oat, hempen cords, &c. Philosophers have sought also to measure the humidity of the air by the augmentation of weight undergone by certain substances, such as tuft of wool, or portions of salt, by absorbing the water contained in the air. But besides that these methods were in themselves very imperfect, the bodies employed were subject to alterations which would make them lose their hygrometric quality more or less promptly. The hygrometer invented by Saussure is free from these inconveniences. The principal piece in it is a hair, which has been divested of a kind of oiliness that is natural to it, by boiling it in water holding in solution nearly a hundredth part of its weight of sulphate of soda. It is known that humidity lengthens the hair, and that the process of drying shortens it. To render both these effects more perceptible, he attached one of the two ends of the hair to a fixed point, and the other to the circumference of a moveable cylinder, that carries at one of its extremities a light index or hand. The hair is bound by a counter-weight of about three grains, suspended by a delicate silk which is rolled in a contrary way about the same cylinder. In proportion as the hair lengthens or shortens, it causes the cylinder to turn in one or the other direction, and by a necessary consequence, the little index turns likewise, the motions of which are measured on the circumference of a graduated circle, about which the index performs its revolution as in common clocks. To give to the scale such a basis as may establish a relation between all the hygrometers constructed upon the same principles, Saussure assumes two fixed terms, the extremity of humidity, and that of dryness; he determines the first by placing the hygrometer under a glass receiver, the whole interior surface of which he had completely moistened with water. To obtain the contrary limit of extreme dryness, he made use of a hot and well-dried receiver, under which he included the hygrometer, with a piece of iron plate likewise heated, covered with a fixed alkali. The scale of the instrument is divided into a hundred degrees. The zero indicates the limit of extreme dryness, and the number one hundred that of extreme humidity. The effects of moisture and of dryness upon the hair, are however modified by those of heat, which act upon it, sometimes in the same sense, and sometimes in a contrary one. In observations which require great precision, it is therefore necessary to consult the thermometer; and on this account, the inventor has constructed from observation a table of corrections.

De Luc employed for the construction of his hygrometers a very thin slip of whalebone, which performs the same office as the hair in that of Saussure. He kept this whalebone bent by means of a spring, the action of which he preferred to that of a weight; he determined the degree of extreme humidity, by immersing the slip of whalebone entirely under water; and to fix the opposite limit, (that of extreme dryness,) he made use of calcined lime, enclosed with the hygrometer under a glass bell.

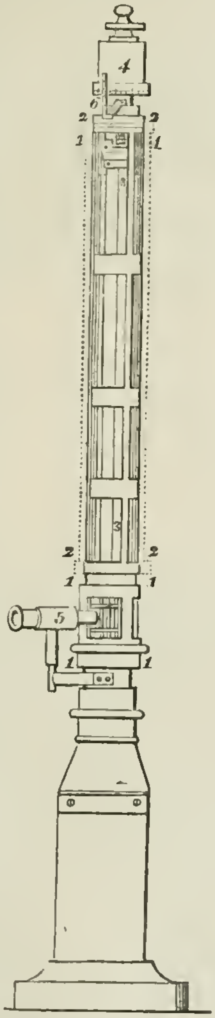
As the hair hygrometer of M. de Saussure has been almost invariably used by the continental philosophers, as the most accurate instrument for measuring the moisture of the air, any real improvement upon it will be regarded by the experimental philosopher as a valuable acquisition to science. The hygrometer of M. Babinet seems to possess this character in no inconsiderable degree, and as a very favourable report upon it has been made to the Academy of Sciences by a very competent judge, M. Fresnel, we shall submit to our readers a drawing and description of it, abridged from the *Journal de Pharmacie* for April, 1824.

This instrument is represented in the annexed figure, where I, I, I, I, is a copper cylinder, resting upon a pedestal, and having large apertures cut out of it. When the interior of the instrument is to be shut up from the external air, its upper part is surrounded with a cylinder of glass, 2, 2, 2, 2, fixed at its two ends (with green wax) to the upper rings which project round the cylinder.

Three hairs, 3, 3, 3, fixed to a micrometer screw, 4.4, placed on the upper part of the instrument, and each stretched by a copper weight, descend into the cylinder, and pass through three holes, in a small horizontal plane, in order that they may be kept separate from each other. On one side of the instrument is placed a small telescope, 5, having a wire in its field, for indicating, with great accuracy, the position of a mark on the copper weights, and ascertaining when the marks have descended to the same point.

The object of the micrometer screw is to measure the elongation of the hairs, which it does nearly to the 2500dth part of an inch, by the usual and well-known process.

In graduating the instrument, extreme dryness is obtained by means of sulphuric acid, and extreme humidity by means of aqueous vapour; and the elongation of the hairs in passing from the state in which they are saturated with moisture to that of extreme dryness, is measured by the micrometer screw. If this elongation is five millimetres, or about one fifth of an inch, this space is represented by 100 degrees of the scale; so that $\frac{5}{100}$dths of a millimetre will correspond to one degree of the scale. When the instrument is thus prepared for use, the glass cylinder is removed, and the hairs exposed to the air, the humidity of which will be indicated by the distance of the mark on the copper weight from the beginning or zero of the scale.



The advantages of this form of the instrument are thus enumerated by its inventor.

1. The extreme delicacy of the indications which are obtained by the telescope and the micrometrical screw, and by the use of three hairs, which are three hygrometers, the mean of the changes of which affords a much greater degree of accuracy than if a single one were used.

2. The removal of the error which arises from the friction and play of the axis of the needle in common hygrometers, as well as from the bending of the hair round the small pulley.

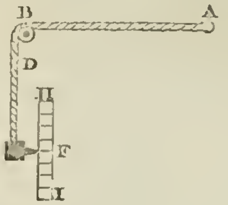
3. The facility of measuring the hygrometrical elongation of any substance, whether flexible or not, when reduced to a slender cylinder, and of comparing two hygrometric substances.

4. In this instrument, the three hairs, which are three hygrometers, agree nearly with one another, while two common hygrometers require very great precaution in order to agree with one another, even less perfectly.

5. This instrument becomes very portable by stopping the weights attached to the three hairs by a small pin which passes through them, and supports them while they are carried about.

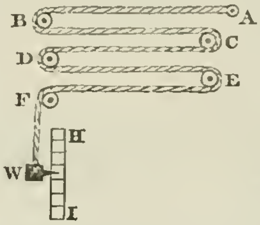
A simple hygrometer may be formed by means of a flaxen line five-feet long; and having a graduated scale fixed to an index moving on a fulcrum. The length of the index, from the fulcrum to the point, should be ten inches; that of the lever, from the fulcrum to the middle of the eye, to which the cord is fixed, two and a half. The air becoming moist, the cord imbibes its moisture; the line in consequence is shortened, and the index rises. On the contrary, the air becoming dry, the cord discharges its moisture,—lengthens,—and the index falls.

Hygrometers are constructed in a great variety of ways, according to the substances of which they are composed, or the manner in which they are designed to act. Our limits however will only allow of touching very slightly on this subject, and we shall therefore confine our remarks to one or two of the best instruments of this kind; after having first illustrated their principle of operation by one of the most simple construction, as follows:



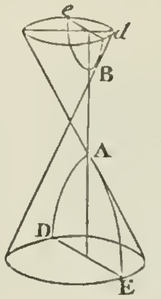
Stretch a common cord or catgut string A B D along a wall, passing it over a pulley B, after having fixed it at one end A, and attached a weight to the other end C, which is made to carry an index or style F. Against the same wall fix a metal graduated plate H I, on which will be indicated the state of the atmosphere by the position of the index, the motion of the latter arising solely from the contraction or dilation of the cord, which takes place according to the degree of dryness or moisture of the atmosphere.

This instrument is as simple as can be desired, and its scale of variation may be increased, by passing it over three or four pulleys, as in the annexed figure; but it is far from possessing that degree of accuracy which is so much to be desired in philosophical instruments and observations, and accordingly various other hygrometers have been invented, to remedy the defect of that above described; one great imperfection of which is, that different instruments, however correct their operation may be, are incomparable with each other; it was therefore a great desideratum to construct them so as to admit of the same kind of comparison as the thermometer and barometer. The most complete instrument of this kind has been invented by J. F. Daniel, Esq. F.R.S. and to his Meteorological Essays we shall therefore have recourse for the drawings and descriptions of this instrument, when we come to treat on the subject of METEOROLOGY in the sequel of our Dictionary.



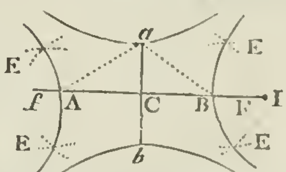
HYMENOPTERA, in Natural History, the fifth order of insects, according to the Linnæan system. They are furnished with four membranaceous wings, and with a sting, or a process resembling one.

HYPERBOLA, is one of the conic sections formed by the intersection of a plane and cone, when the plane makes a greater angle with the base of the cone, than that formed by the base and side of the cone, as D A E.

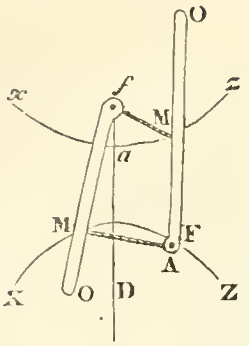


And if the plane be produced so as to cut the opposite cone, another hyperbola will be formed, as *d* B *e*, which is called the opposite hyperbola to the former.

The hyperbola, like all the other conic sections, may be treated of in three different ways, *viz.* 1. As being produced by the intersection of a plane and cone; 2. according to its description in plano; and 3. As being generated by the motion of a variable line or ordinate along another line or directrix, whereby the properties of the curve are treated of, from the equation by which it is defined.

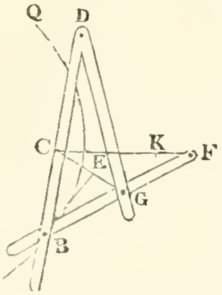


Mechanical Description of the Hyperbola, and the Method of drawing the Figure.—1. In the transverse axis AB, produced, take the foci F, *f*; or, which is the same, take C F, C *f*, both = A *a* or B *a*; assume any point I, and with the radii A I, or B I, and centres F, *f*, describe arcs intersecting in E, which will give four points in the curve; then find other points in the same manner, and the curve passing through those points will be the hyperbola required.



2. If one end of a ruler *f* M O, be fastened at the point *f* by a pin on a plane, so as to turn freely about that point as a centre; and a thread F M O shorter than the ruler be fixed, one end at F, and the other to the end O of the ruler:

Then if the ruler *f* M O be turned about the fixed point *f*, at the same time that the thread F M O is kept always tight, and its part M O close to the side of the ruler by means of the pin M, the curve line A X resulting from the motion of the pin M, is one part of an hyperbola; and if the ruler be turned, and move on the other side of the fixed point F, the other part A Z of the same hyperbola may be described after the same manner.—Or otherwise.



3. Let C and F be the two foci, and E and K the two vertices of the hyperbola. Take three rulers C D, D G, G F, so that C G = G F = E K, and D G = C F; let the rulers C D, G F, be of an indefinite length beyond C and G, and having slits in them for a pin to move in the rulers, having holes in them at C and F, by which with pins they are fastened to the foci of those points, being joined to the points D and G by the ruler D G. Then if a pin be put in the slits, *viz.* the common intersection of the rulers C D, and G F, and moved along, causing the two rulers G F, C D, to turn about the foci C and F; that point will describe the portion E Q of an hyperbola. Other mechanical methods of describing this curve may be seen in various works.

Hyperbolas receive various denominations from certain peculiarities in their construction, proportions, &c.; as *acute*, *ambigenal*, *equilateral*, &c.

HYPERBOLE, in Rhetoric, a figure whereby the truth and reality of things are excessively enlarged, or diminished.

HYPERBOLIC LINE, is used by some authors for what we call the hyperbola itself.

HYPERBOLIC *Logarithms*, or *Naperian Logarithms*, are a series of numbers particularly useful in the determination and computation of fluents, arising from various problems in the higher branches of the mathematics; having, at the same time, the property of common logarithms in facilitating arithmetical operations.

These numbers are termed hyperbolic logarithms, because they express the areas or spaces contained between the assymptote and curve of the hyperbola; but as this property is not peculiar to this system, they are now more commonly called Naperian logarithms, from the name of the illustrious inventor of this method of computation.

HYPOTHECATE, in Law. To hypothecate a ship, is to pawn the same for necessaries: and a master may hypothecate either ship or goods for relief, when in distress at sea.

HYPOTHENUSE, in Geometry, the longest side of a right-angled triangle; or it is that side which subtends the right angle. In every rectilinear right-angled triangle, the square of the hypothenuse is equal to the squares of both the other sides, by the 47th prop. of the first book of Euclid.

HYPOTHESIS, in general, denotes something supposed to be true, or taken for granted, in order to prove or illustrate a point in question.

HYSTRIX, *Porcupine*, in Natural History, a genus of quadrupeds of the order glires. There are five species. H. crista, or the common porcupine, is about two feet in length, exclusively of the tail. It is found in Africa and India, and in the warmer climate of Europe. It is covered on the upper part of its body with variegated spines or quills, which are long and sharp, and which, when irritated, it erects with particular intenseness, and a rustling and alarming noise. Its principal food consists of the bark of trees, roots, and fruit. It produces two at a birth, and if taken young is tamed with considerable facility. Its flesh is eaten not only in Africa but in Italy, and is thought extremely luscious.

The Brazilian porcupine is about a foot long, and its tail about a foot and a half, by which it clings to the branches of trees. It is covered with strong, short, and extremely sharp spines, on most of those parts of its body particularly exposed to assault.

I.

I, or i, the ninth letter and third vowel of the alphabet. When used as a numeral, it signifies no more than one, and stands for so many units as it is repeated times; thus I, one; II, two; III, three, &c. and when put before a higher numeral it subtracts itself, as IV, four; IX, nine, &c.; but when set after it, so many are added to the higher numeral as there are I's added; thus, VI is 5 + 1, or six; VII, 5 + 2, or seven; VIII, 5 + 3, or eight. The ancient Romans likewise used IↃ for 500, CIↃ for 1000, IↃↃ for 5000, CCIↃↃ for 10,000, IↃↃↃ for 50,000, and CCCIↃↃↃ for 100,000. Farther than this, as Pliny observes, they did not go in their notation; but when necessary, repeated the last number, as CCCIↃↃↃ, CCCIↃↃↃ for 200,000; CCCIↃↃↃ, CCCIↃↃↃ, CCCIↃↃↃ for 300,000; and so on.

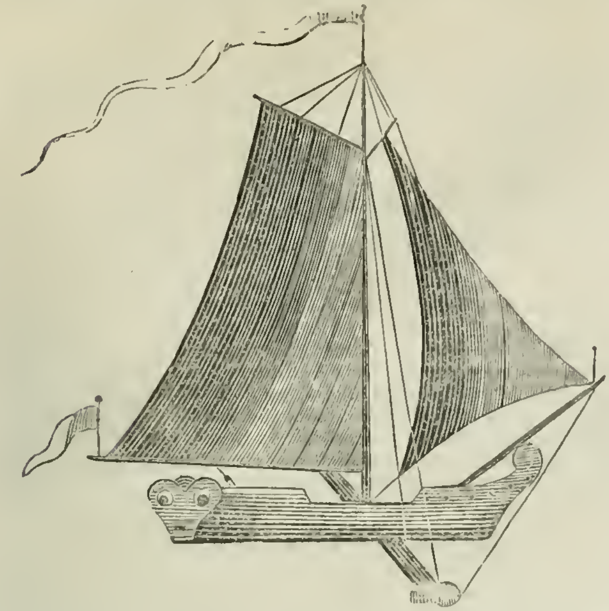
IAMBICS, certain songs or satires, which are supposed to have given birth to the ancient comedy. The word is applied also to a particular kind of Latin verse, of which the simple foot consists of a short and long syllable.

IBEX, in Zöology. *See* CAPRA.

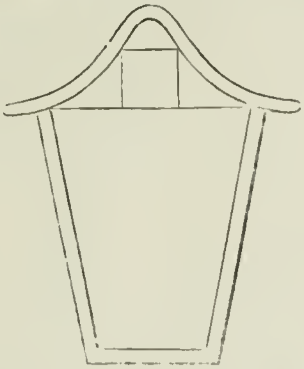
ICE, a brittle transparent body, formed of some fluid frozen or fixed by cold. The specific gravity of ice to that of water, is in about the ratio of ·93 to 1; and the capacity for heat as ·9 to 1; its refractive power is 1·31, being the least so of any known substance that is not aëriform. *See* FREEZING and FREEZING *Mixture;* and for the expansive power of water in passing from its liquid state, *see* EVAPORATION and EXPANSION.

ICE *Cream, To make.* Take a sufficient quantity of cream, and when it is to be mixed with raspberry or currant juice, a quarter part as much of the juice or jam, as of the cream. After beating and straining the mixture through a cloth, put it with a little juice of lemon into the mould, (a pewter vessel, and varying in size and shape at pleasure:) cover the mould, and place it in a pail about two-thirds full of ice, into which two handfuls of salt have been thrown, turn the mould by the hand-hold with a quick motion to and fro, in the manner used in milling chocolate, for 8 or 10 minutes; then let it rest as long, and turn it again for the same time; and having left it to stand for half an hour, it is then fit to be turned out of the mould and set upon the table. Lemon juice and sugar, and the juices of various kinds of fruits are frozen without cream; and when cream is used, it should be well mixed.

ICE *Boats* are so constructed as to sail upon ice, and they are common in Holland upon the Maese and lake Y. This figure represents one of these useful conveyances of goods and passengers, whose breath is sometimes, however, affected by the rapid velocity at which this machine is driven



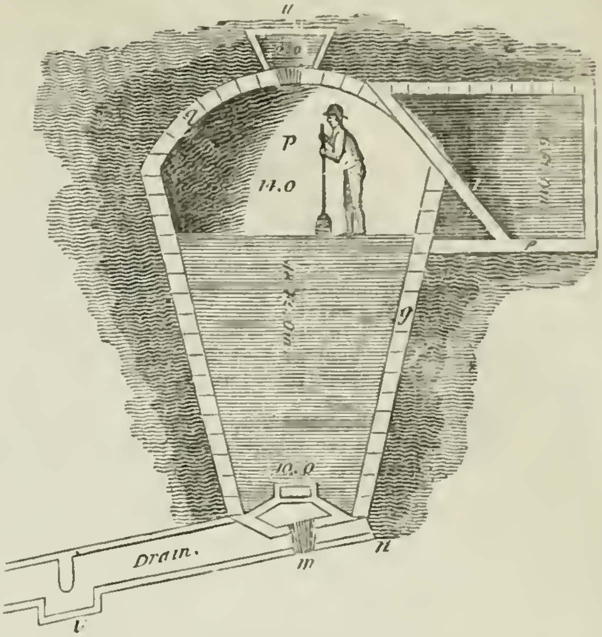
Ice *House.* The simplest form of an ice house is the following improvement upon the Italian and American plans:—In a soil where and springs do not strike above 16 feet deep, dig a pit 12 feet deep, and about 18 feet square. You may then erect a frame similar to the figure. The posts ought to be about 9 inches in diameter, placed near enough to each other for thin laths to be nailed upon them, and the inside dressed to an acute angle, so that as little wood as possible may touch the ice. On the inside let thin laths be nailed at about two feet apart; on the outside, at moderate distances, nail rough boards, and fill the place within with wheat or rye straw set on end. The inside of the roof to be made in the same way, and also the gables. Straw to be sewed on the inside, and heath or straw on the outside of the door. The outside of the roof to be thatched thick with straw or heath; and heath, brushwood, or fir tops, to be filled in between the outside boarding and the surrounding ground, and then neatly thatched or turfed over. The bottom of the house, for 2 feet deep, to be laid with large logs or stones, next with heath, fir tops, or brushwood, and then with straw. The ice house, when thus completed, will look like a square bee-hive inverted, and is then ready to receive the ice or snow

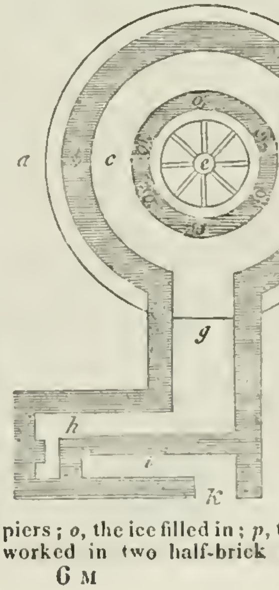


Unless the house is in a very shady place, it may be necessary to extend the roof, where the door is placed, 5 or 6 feet, making a second gable and door, finished in the same way as the first, and fill up the intervening space, except a passage, with heath or straw.

The best soil for an ice house to be made in is chalk, as it conveys away the waste water without any artificial drain; next to that, loose stony earth or gravelly soil. Its situation should be on the side of a hill, for the advantage of entering the cell upon a level, as in the drawing.

To construct an ice house, first choose a proper place at a convenient distance from the dwelling-house, or house it is to serve; dig a cavity (if for one family, of the dimensions specified in the design) of the figure of an inverted cone, sinking the bottom concave, to form a reservoir for the waste water till it can drain off: if the soil requires it, cut a drain to a considerable distance, or so far as will come out at the side of the hill, or into a well, to make it communicate with the springs, and in that drain form a stink or air-trap, marked *l*, by sinking the drain so much lower in that place as it is high, and bring a partition from the top an inch or more into the water, which will consequently be in the trap, and will keep the well air-tight. Work up a sufficient number of brick piers to receive a cart wheel, to be laid with its convex side upwards to receive the ice; lay bundles of straw upon the wheel, which will let the melted ice drain through, and serve as a floor. The sides and dome of the cone are to be nine inches thick—the sides to be done in steened brickwork, *i. e.* without mortar, and wrought at right angles to the face of the work: the filling in behind should be with gravel, loose stones, or brickbats, that the water which drains through the sides may the more easily escape into the well. The doors of the ice house should be made as close as possible, and bundles of straw placed always before the inner door to keep out the air.





Description of the parts referred to by the letters:—*a*, the line first dug out; *b*, the brick circumference of the cell; *c*, the diminution of the cell downwards; *d*, the lesser diameter of the cell; *e*, the cart wheel or joists and hurdles; *f*, the piers to receive the wheel or floor; *g*, the principal receptacle for straw; *h*, the inner passage; *i*, the first entrance; *k*, the outer door, passages having a separate door each; *l*, an air trap, as in the upper figure; *m*, the well; *n*, the profile of the piers; *o*, the ice filled in; *p*, the height of the cone; *q*, the dome worked in two half-brick arches; *r*, the arched passage; *s*, the door-ways inserted in the walls; *t*, the floor of the passage; *u*, an aperture through which the ice may be put into the cell. This must be covered next the crown of the dome, and then filled in with the earth. *x*, the sloping door, against which the straw should be laid. The ice, when to be put in, should be collected during the frost, broken into small pieces, and rammed down hard in strata of not more than a foot, in order to make it one complete body; the care in putting it in, and well ramming it, tends much to its preservation. In a season when ice is not to be had in sufficient quantities, snow may be substituted.

Mode of filling the House.—When the ice, or snow, if ice cannot be procured, is put into the house, it must be well beaten down with a pavier's rammer, or mallet, and the surface *always kept concave*; by this means any snow or ice that may melt will run to the middle, or interstices, and freeze. For the same reason, the surface of the ice ought always to be kept concave when ice is taken out for use.

Should the frost be very intense, when the ice house is getting filled, it may be very beneficial at the close of each day's filling to throw in 30 or 40 pails full of water, which will fill the interstices and freeze.

When the house is full, spread upon the *concave* surface a carpet, or sail, split up the middle, and put upon the top thereof a foot thick of straw.

When ice is required for the use of the family, or when it is necessary to put in fresh meat to lie on the face of the ice for preservation, or to take out for use, the straw and carpet, or sail, to be opened at the middle.

Should rats infest the place, an iron wire frame or case may be required to put the meat or fish, &c. into, when lying on the ice.

A small open surface drain ought to be dug round the house, to prevent any water running into it.

Opening the door of the house does little harm. Damp or dense substances touching the ice is much more prejudicial than dry air.

ICH DIEN, a motto of the Prince of Wales's arms, signifying, in the High Dutch, "I serve." The three ostrich feathers, and the motto *Ich Dien*, were worn by the king of Bohemia, slain by the Black Prince in the battle of Crecy, and were adopted as a memorial of the victory.

ICHNOGRAPHY, in Perspective, the view of any thing cut off by a plane, parallel to the horizon, just at the base of the object. Among painters, it signifies the descriptions of images, or of ancient statues of marble, copper, or bronze, of busts and semi-busts, of paintings in fresco, mosaic works, and ancient pieces of miniature.

ICHNOGRAPHY, in Architecture, is a transverse or horizontal section of a building, exhibiting the plot of the whole edifice, and of the several rooms or apartments in any story, together with the thickness of the walls and partitions, the dimensions of the doors, windows, chimney pieces, recesses, alcoves, the projections of all columns and piers, with every thing visible in such a section.

ICHTHYOLOGY, that part of zöology which treats of fishes, their history, anatomy, physiology, and habitudes; and which offers a systematic exposition of all the finny tribe. *See* FISHES.

ICONOCLASTS, in Church History, an appellation given to those persons who, in the 8th century, opposed image worship.

ICOSAHEDRON, in Geometry, one of the regular platonic bodies, comprehended under twenty equal triangular sides or faces. Or, an icosahedron may be conceived to consist of twenty equal triangular pyramids, whose vertices or tops unite in one common point, which will be the centre of the circumscribing sphere.

To find the Surface and Solidity of an Icosahedron, the Side of one of its equal Faces being given.—Let *s* represent the given side; then will

$$\text{surface} = 5s^2\sqrt{3} = 8{\cdot}66025403\,s^2$$

$$\text{solidity} = \tfrac{5}{6}s^3\sqrt{\frac{7+3\sqrt{5}}{2}} = 2{\cdot}1816950\,s^3$$

The Radius of the Sphere circumscribing an Icosahedron being given, to find its Side or Linear Edge, Surface, and Solidity.—Let R represent the given radius, then will

$$\text{side} \ldots\ldots\ldots\ldots = R\sqrt{\left(\frac{10-2\sqrt{5}}{5}\right)}$$

$$\text{surface} \ldots\ldots\ldots = 2R^2(5\sqrt{3}-\sqrt{15})$$

$$\text{solidity} \ldots\ldots\ldots = \tfrac{2}{3}R^3\sqrt{(10+2\sqrt{5})}$$

Or putting *r* to represent the radius of the inscribed sphdre, we shall have

$$\text{side} \ldots\ldots\ldots\ldots = r\sqrt{(42-18\sqrt{5},}$$

$$\text{surface} \ldots\ldots\ldots = 2r^2(7\sqrt{3}-3\sqrt{15})$$

$$\text{solidity} \ldots\ldots\ldots = 10r^3(7\sqrt{3}-3\sqrt{15})$$

Or writing *s* for the side, we have

$$\text{radius circum. sphere} = \tfrac{1}{2}s\sqrt{\left(\frac{5+\sqrt{5}}{2}\right)}$$

$$\text{radius inscrib. sphere} = \tfrac{1}{2}s\sqrt{\left(\frac{7+3\sqrt{5}}{6}\right)}$$

IDES, in the Roman Calendar, were certain days in each month, which commenced on the fifteenth day of March, May, July, and October, but on the thirteenth in all the other months. The Romans had also the kalends and nones. The first day of the month was called *kalendæ*; and the 7th of March, May, July, and October, was called the *nonæ*; but in all the other months of the year the 5th was called the *nonæ*. In reckoning they went back, as is shewn in the following table.

A TABLE *of the Kalends, Nones, and Ides.*

Days of the Month.	April, June, September, November.		January, August, December.		March, May, July, October.		February.	
1	Kalendæ.		Kalendæ.		Kalendæ.		Kalendæ.	
2	IV. No-		IV. No-		VI.	Nonas.	IV No-	
3	III. nas.		III. nas.		V.		III. nas.	
4	Prid. Non.		Prid. Non.		IV.		Prid. Non.	
5	Nonæ.		Nonæ.		III.		Nonæ.	
6	VIII.	Idus.	VIII.	Idus.	Prid. Non.		VIII.	Idus.
7	VII.		VII.		Nonæ.		VII.	
8	VI.		VI.		VIII.	Idus.	VI.	
9	V.		V.		VII.		V.	
10	IV.		IV.		VI.		IV.	
11	III.		III.		V.		III.	
12	Prid. Id.		Prid. Id.		IV.		Prid. Id.	
13	Idus.		Idus.		III.		Idus.	
14	XVIII.	Calendas.	XIX.	Calendas.	Prid. Id.		XVI.	Calendas.
15	XVII.		XVIII.		Idus.		XV.	
16	XVI.		XVII.		XVII.	Calendas.	XIV.	
17	XV.		XVI.		XVI.		XIII.	
18	XIV.		XV.		XV.		XII.	
19	XIII.		XIV.		XIV.		XI.	
20	XII.		XIII.		XIII.		X.	
21	XI.		XII.		XII.		IX.	
22	X.		XI.		XI.		VIII.	
23	IX.		X.		X.		VII.	
24	VIII.		IX.		IX.		VI.	
25	VII.		VIII.		VIII.		V.	
26	VI.		VII.		VII.		IV.	
27	V.		VI.		VI.		III.	
28	IV.		V.		V.		Prid. Kal. Martii.	
29	III.		IV.		IV.			
30	Prid. Kal.		III.		III.			
31	Mens. Seq.		Prid. Kal. Mens. Seq.		Prid. Kal. Mens. Seq.			

IDENTITY, denotes that by which a thing is itself and not any thing else.

IDIOM, among grammarians, properly signifies the peculiar genius of each language, but is often used in a synonymous sense with dialect.

IDIOSYNCRASY, among physicians, denotes a peculiar temperament of body, whereby it is rendered more liable to certain disorders than persons of a different constitution usually are.

IDIOTS, in Law. An idiot is a fool or madman from his nativity. According to the statute of 17 Edward II. c. 9, the king shall have the custody of the lands of natural fools, taking the profits of them without waste or destruction, and shall find them necessaries. And after the death of them he shall render it to the right heir. But it seldom happens that a jury finds a man an idiot from his nativity, but only *non compos mentis*, from some particular time; in which case he comes under the denomination of a lunatic, of whose lands the king shall not have the profit, but is accountable for the same to the lunatic when he comes to his right mind, or to his executors or administrators. An idiot, or person *non compos*, may inherit and purchase; and if he marry and die, his wife shall be endowed. It is a general rule, that idiots and lunatics being incapable of judging between good and evil, are punishable by no criminal prosecution whatsoever. Acts solemnly acknowledged by them in a court of record, as fines and recoveries, and the uses declared on them, are good, and cannot be avoided by themselves or representatives. But during their lunacy, they are incapable of making any will or testament, as are also persons grown childish from extreme old age. When an idiot sues or defends he must appear: but a lunatic shall appear by guardian or by attorney.

IGNIS FATUUS, a common meteor, chiefly seen in dark nights, frequenting meadows, marshes, and other moist places, and often seen in burying-grounds and near dunghils. It is known among the country-people by the appelation of *Will with a Wisp* and *Jack with a Lantern.* Sir Isaac Newton calls it a vapour shining without heat; and it has been supposed to be of the same nature with the light issuing from putrescent substances. Willoughby and Ray were of opinion that it is occasioned by shining insects; but all the appearances of it observed by Dr. Derham, Beccaria, and others, sufficiently evince that it must be an ignited vapour. The form and size of the *ignes fatui* are very various and often variable. The late experiments on air serve to furnish a rational explication of this phenomenon, to which the ignorant and superstitious have ascribed so many alarming purposes. Inflammable air has been found to be the most common of all the factitious airs in nature, and to be the usual product of the putrefaction and decomposition of vegetable substances in water; and Signior Volta, in a letter to Dr. Priestley, informs him that he fires inflammable air by the electric spark, even when the electricity is very moderate; and he supposes that this experiment explains the inflammation of the *ignes fatui*, provided they consist of inflammable air issuing from marshy ground, by the help of the electricity, of fogs, and by falling stars, which are very probably thought to have an electrical origin.

Dr. Shaw describes an *ignis fatuus*, which he saw in the Holy Land, that was sometimes globular, or in the form of the flame of a candle, and immediately afterwards spread itself so much as to involve the whole company in a pale inoffensive light, and then contract itself again, and suddenly disappear. But in less than a minute it would become visible as before; or, running along from one place to another with a swift progressive motion, would expand itself at certain intervals over more than two or three acres of the adjacent mountains. The atmosphere at this time had been thick and hazy; and the dew on their bridles was usually clammy and unctuous. At sea also, in similar weather, he observed those electrical luminous appearances skip about the masts and yards of ships, and which may also frequently be seen playing at night on the arms of soldiers encamped in low grounds.

IGNITION, the application of fire to metals, till they become red-hot without melting. Ignition takes place in gold, silver, and iron; but lead and tin melt before they are red-hot.

ILEX, in Botany, holly, a genus of the tetrandria tetragynia class and order.—Natural order of Dumosæ. Rhamni, Jussieu. There are sixteen species. This genus consists of small trees, shrubs with alternate leaves, evergreen, toothed, or thorny; and axillary, many-flowered peduncles. I. Aquifolium, common holly, is usually from twenty to thirty feet in height, though it sometimes exceeds sixty feet. The holly makes an impenetrable fence, and bears cropping well, nor does its verdure suffer from the severest of our winters. The wood is the whitest of all hard woods. Sheep and deer are fed during the winter with the croppings. Birds eat the berries.—The bark fermented and afterwards washed from the woody fibres, makes the common birdlime.

ILIAC PASSION, a violent dangerous kind of cholic; called also *valvulus, miserere mei*, and *chordapsus.* It takes its name from the intestine *ilion*, on account of its being usually affected in this distemper; or perhaps from the Greek verb *ειλειν*, "to wind or twist;" whence also the Latins call it *valvulus.*

ILLECEBRUM, a genus of plants belonging to the pentandria class, and in the natural method ranking under the 12th holoraceæ.

ILLICIUM, a genus of plants belonging to the decandria class; and in the natural method ranking with those of which the order is doubtful.

ILLUMINATING, a kind of miniature painting, anciently much practised for illustrating and adorning books. Besides the writers of books, there were artists whose profession was to ornament and paint manuscripts, who were called illuminators; the writers of books first finished their part, and the illuminators embellished them with ornamented letters and paintings. We frequently find blanks left in manuscripts for the illuminators, which were never filled up. Some of the ancient manuscripts are gilt and burnished in a style superior to later times. Their colours were excellent, and their skill in preparing them must have been very great.

ILLUMINATION, that which results from, or the effect of, a luminous body.

IMAGE, in Optics, is the appearance of an object made either by reflection or refraction. *See* LENS, MIRROR, REFLECTION, and REFRACTION.

IMAGE, in a religious sense, is an artificial representation or similitude of some person or thing, used either by way of decoration and ornament, or as an object of religious worship and adoration; in which last sense it is used indifferently with the word Idol. The noble Romans preserved the images of their ancestors with a great deal of care and concern, and had them carried in procession at their funerals and triumphs; these were commonly made of wax, or wood, though sometimes of marble or brass. They placed them in the vestibule of their houses; and they were to stay there, even if the houses happened to be sold, it being accounted impious to displace them

IMAGE, in Rhetoric, also signifies a lively description of any thing in discourse.

IMAGES, in discourse, are defined by Longinus to be, in general, any thoughts proper to produce expressions, and which present a kind of picture to the mind. But in the more limited sense, he says, images are such discourses as come from us, when, by a kind of enthusiasm, or an extraordinary emotion of the soul, we present them before the eyes of those who hear us.

IMAGES, in Rhetoric, have a very different use from what they have among the poets; the end principally proposed in poetry is, astonishment and surprise; whereas the thing chiefly aimed at in prose, is to paint things naturally, and to shew them clearly. They have this, however, in common, that they both tend to move, each in its kind.

These *Images* or *Pictures* are of vast use to give weight, magnificence, and strength, to a discourse. They warm and animate it; and when managed with art, according to Longinus, seem, as it were, to tame and subdue the hearer, and put him in the power of the speaker.

IMAGINARY QUANTITIES, or *Impossible Quantities*, in Algebra, are certain expressions that arise in various algebraical and trigonometrical operations, to which no value either rational or irrational can be assigned, yet being substituted in the equation whence they were deduced, they are found to answer the condition of the question.

IMAGINATION, a power or faculty of the mind, whereby it conceives and forms ideas of things communicated to it by the outward organs of sense. Though the fancy and the imagination are nearly allied, yet these faculties are distinct.

IMAM, or IMAN, a minister in the Mahometan church, answering to a parish priest among us. The word properly signifies what we call a prelate, *antistes*, one who presides over others; but the Mussulmen frequently apply it to a person who has the care and intendancy of a mosque, who is always first there, and reads prayers to the people, which they repeat after him. Imam is also applied, by way of excellence, to the four chiefs or founders of the four principal sects in the Mahometan religion. Thus, Ali is the Imam of the Persians, or of the sect of the Schiates; Abu-beker the Imam of the Sunites, which is the sect followed by the Turks; Saphii or Saf-y, the Imam of another sect, &c.

IMBECILITY, a languid infirm state of the body, which being greatly impaired, is not able to perform its usual exercises and functions.

IMBEZZLE, signifies to steal or secrete goods, &c. intrusted to a person's charge. Servants embezzling their masters' goods to the value of 40s. are guilty of felony, and subject to transportation.

IMBIBING, the action of a dry porous body, that absorbs or takes up a moist or fluid one: thus sugar imbibes water; a sponge, the moisture of the air, &c.

IMBRICATED, is used by some botanists, to express the figure of the leaves of some plants which are hollowed like an *imbrex*, or gutter-tile, or are laid in close series over one another like the tiles of a house.

IMITATION, derived from the Latin *imitare*, "to represent or repeat," a sound or action, either exactly or nearly in the same manner as they were originally exhibited.

Imitation, in Music, admits of two different senses; sound and motion are either capable of imitating themselves by a repetition of their own particular modes, or of imitating other objects of a nobler and more abstracted nature.

Imitation, in Oratory, is an endeavour to resemble a speaker or writer, in those qualities with regard to which we propose them to ourselves as patterns. The first historians among the Romans, says Cicero, were very dry and jejune, till they began to imitate the Greeks, and then they became their rivals. It is well known how closely Virgil has imitated Homer in his Æneid, Hesiod in his Georgics, and Theocritus in his Eclogues. Terrence copied after Menander; and Plautus after Epicarmus, as we learn from Horace, lib. ii. ad Augus. who himself owes many of his beauties to the Greek lyric poets. Cicero appears, from many passages in his writings, to have imitated the Greek orators. Thus Quintilian says of him, that he has expressed the strength and sublimity of Demosthenes, the copiousness of Plato, and the delicacy of Socrates.

IMITATIVE, in Music, a term applicable to that music which is composed in imitation of the effects of some of the operations of nature, art, or human passion.

IMMATERIAL, something devoid of matter, or that is pure spirit.

IMMEMORIAL, in Law, an epithet given to the time or duration of any thing whose beginning we know nothing of. In a legal sense, a thing is said to be of time immemorial, that was before the time of King Edward II.

IMMENSITY, an unlimited extension, or which no finite and determinate space, repeated ever so often, can equal.

IMMERSION, in Astronomy, is when a planet, comet, or other heavenly body approaches so near to conjunction with the sun, that it is enveloped in his rays, and lost to our observation. Immersion also denotes the beginning of an eclipse, or of an occultation, when the body or any part first begin to disappear, either behind another body or in its shadow; as in an eclipse of the sun, when the disc is first covered by the edge of the moon; or as in an eclipse of the latter body, when she first enters the terrestrial shadow.

IMMUTABILITY, one of the divine attributes. The immutability of God is two-fold, physical and moral. The first consists in this, that the divine essence does not, nor possibly can, receive any alteration; and the moral immutability is founded on the perfection of his nature, whereby he always wills the same things, or such as are best on the whole.

IMPALPABLE, that whose parts are so extremely minute that they cannot be distinguished by the senses, particularly by that of feeling.

IMPANNELING, in Law, signifies the writing down or entering into parchment list, or schedule, the names of a jury summoned by the sheriff to appear for such public services as juries are employed in.

IMPARLANCE, in Law, a petition in court for a day to consider or advise what answer the defendant shall make to the plaintiff's action, and is the continuance of the cause till another day, or a longer time given by the court.

IMPASSIBLE, that which is exempt from suffering; or which cannot undergo pain or alteration. The Stoics place the souls of their wise men in an impassible, imperturbable state.

IMPASTATION, the mixture of various materials of different colours and consistencies, baked or bound together with some cement, and hardened either by the air or by fire.

IMPATIENS, *Touch-me-not*, and *Balsamine*, a genus of plants belonging to the syngenesia class; and in the natural method ranking under the 24th order, corydales.

IMPEACHMENT, an accusation and prosecution for treason, and other crimes and misdemeanours. Any member of the lower house of parliament may impeach any one belonging either to that body or to the house of lords. The method of proceeding is to exhibit articles on the behalf of the commons, by whom managers are appointed to make good their charge. These articles are carried to the lords, by whom every person impeached by the commons is always tried; and if they find him guilty, no pardon under the great seal can be pleaded to such an impeachment, 12 William III. cap. 2. The most celebrated impeachment in our own times was that of the late Warren Hastings.

Impeachment of Waste, signifies a restraint from committing of a waste upon lands and tenements

IMPEDIMENTS, in Law, are such hinderances as put a stop or stay to a person seeking for his right by due course of law. Persons under impediments, are those under age or coverture, *non compos mentis*, in prison, beyond the sea, &c. &c. who, by a saving in our laws, have time to claim and prosecute their rights, after the impediments are removed, in case of fines levied, &c.

IMPENETRABILITY, forms a discriminating feature of body. This principle is commonly regarded as an axiom, but it is a truth derived from early and invariable experience. It rests on the incontrovertible fact, that no two bodies can occupy the same space in the same precise instant of time. Had the case indeed been otherwise, each body might be successively absorbed into the substance of another, till the whole frame of the universe, collapsing into a point, were lost in the vortex of annihilation. But although the most palpable observation sufficiently attests the impossibility of the mutual compenetration of bodies, yet this property may be farther illustrated and confirmed by a few simple experiments. 1. A vessel being filled to the brim with water, if any solid incapable of dissolving in that liquid, be plunged in it, a portion of the water will overflow, exactly equal to the bulk of the wood or metal immersed. 2. If a cylinder be gradually pressed downwards into a glass cylinder partly filled with water, the liquid will rise proportionally, till the space passed over by its surface shall be equal to the portion of the cylinder introduced. These two experiments shew that water opposes the entrance of a solid substance, and retires on all sides to give room for its advance. Simple as the fact appears, it was first distinctly noticed by Archimedes, who made it the ground of his hydrostatical theory.

The same truth is evinced by other experiments. 3. If a cork be rammed hard into the neck of a phial filled with water, the phial will burst, while its neck remains entire. 4. Bladders filled with water, and disposed upon a table, will support very large weights placed on a board which has been laid over them. 5. The same experiment will equally succeed with bladders blown full of air. 6. The disposition of the air to resist all penetration is made conspicuous in another way. Let a large and very tall glass vessel be nearly filled with water, on the surface of which a lighted taper is set to float; if, over this glass, a smaller cylindrical vessel, likewise of glass, be inverted and pressed downwards, the contained air maintaining its place, the internal body of the water will descend, while the rest will rise up at the sides, and the taper will appear for some seconds to burn, encompassed by the whole mass of liquid.

IMPERATIVE, one of the moods of a verb, used when we would command, entreat, or advise.

IMPERFECT, something that is defective, or that wants some of the properties found in other beings of the same kind: thus mosses are called imperfect plants, because almost all the parts of fructification are wanting in them.

Imperfect *Numbers*, such whose aliquot parts taken together do either exceed or fall short of that whole number of which they are parts; they are either abundant or deficient.

IMPETIGENES, in Medicine, descriptive of those disorders which, from a general bad habit, manifest themselves principally by disfiguring the skin and external parts of the body.

IMPETUS, in Mechanics, the force with which one body impels or strikes another.

IMPLEAD, to sue or prosecute by course of law.

IMPLICATION, in Law, is when something is implied that is not expressed by the parties themselves in their deeds, contracts, or agreements.

IMPLY, *To*, or Carry, in Music. These we have used as synonymous terms in that article. They are intended to signify those sounds which ought to be the proper concomitants of any note, whether by its own nature, or by its position in artificial harmony. Thus every note, considered as an independent sound, may be said to carry or imply its natural harmonies, that is to say, its octave, its twelfth, and its seventeenth; or, when reduced, its eighth, its fifth, and its third. But the same sound, when considered as constituting any part of harmony, is subjected to other laws and different limitations. It can only be said to carry or imply such simple sounds, or complication of sound, as the preceding and subsequent chords admit or require. For these the laws of melody and harmony must be consulted. *See* Melody and Harmony.

IMPONDERABLE Substances, are light heat, and electricity, which have no sensible weight.

IMPORTATION, the act of bringing goods into a country from foreign parts. It has generally been considered, that for any country to carry on a profitable trade, it is necessary that the value of the goods sent out of it should be greater than that of the articles imported; this, however, is a very erroneous axiom, unless it is understood with great limitations. All articles of merchandise imported merely for re-exportation, and also such as are used or worked up in our own manufactures, are far from being hurtful to our commerce, and may even, in many respects, be deemed of equal profit with our own native commodities. It is therefore an excess of such importations alone, as are either for mere luxury or mere necessity, or for both together, which is disadvantageous to the country.

IMPOST, in Architecture, a capital or plinth to a pillar or pilaster, or pier that supports an arch, &c.

Impost, in Law, signifies, in general, a tribute or custom, but is more particularly applied to signify that tax which the crown receives for merchandises imported into any port or haven.

IMPOSTHUME, or Abscess, a collection of matter or pus in any part of the body, either owing to an obstruction of the fluids in that part, which makes them change into such matter, or a translation of it from some other part, where it was generated.

IMPOSTOR, in a general sense, denotes a person who cheats by a fictitious character.

Impostors, *Religious*, are such as falsely pretend to an extraordinary commission from heaven, and who terrify and abuse the people with false denunciations of judgments. These are punishable in the temporal court with fine, imprisonment, and infamous corporal punishment.

IMPOTENCE, or Impotency, in general, denotes want of strength, power, or means to perform any thing. Divines and philosophers distinguish two sorts of impotency; natural and moral. The first is a want of some physical principle, necessary to an action; or where a being is absolutely defective, or not free and at liberty to act: the second only imports a great difficulty; as a strong habit to the contrary, violent passion, or the like.

IMPRECATION, (derived from *im* and *precor*, "I pray,") a curse, or wish that some evil may befall any one. The ancients had their goddesses called *imprecations*, in Latin *Diræ*, i. e. *Deorum iræ*, who were supposed to be the executioners of evil consciences. They were called Diræ in heaven, Furies on earth, and Eumenides in hell. The Romans owned but three of these imprecations, and the Greeks only two. They invoked them with prayers and pieces of verses, to destroy their enemies.

IMPREGNATION, the state of a female being with young. *See* Conception. The term impregnation is also used in Pharmacy, for communicating the virtues of one medicine to another, whether by mixture, coction, digestion, &c.

IMPRESSING Seamen. The power of impressing seafaring men for the sea service by the king's commission, has been a matter of some dispute, and submitted to with great reluctance; though it has very clearly and learnedly been shewn by Sir Michael Forster, that the practice of impressing, and granting powers to the admiralty for that purpose, is of a very ancient date, and has been uniformly continued by a regular series of precedents to the present time: whence he concludes it to be part of the common law. The difficulty arises from hence, that no statute has expressly declared this power to be in the crown, though many of them very strongly imply it. The statute 2 Rich. II. c. 4. speaks of mariners being arrested and retained for the king's service, as of a thing well known, and practised without dispute; and provides the remedy against the running away. By a later statute, if any waterman, who uses the Thames, shall hide himself during the execution of any commission of pressing for the king's service, he is liable to heavy penalties. By another, (5 Eliz. c. 5.) no fisherman shall be taken by the queen's commission to serve as a mariner; but the commission shall be brought first to two justices of the peace inhabiting near the sea-coast, where the mariners are to be taken, to the intent that the justices may choose out and return such a number of able-bodied men, as in the commission are contained, to serve her majesty. And by others, especial protections are allowed to seamen in particular circumstances, to prevent them from being impressed. Ferrymen are also said to be privileged from being impressed, at common law. All which do most evidently imply a power of impressing to reside somewhere; and if any where, it must, from the spirit of our constitution, as well as from the frequent mention of the king's commission, reside in the crown alone. After all, however, this method of manning the navy is to be considered as only defensible from public necessity, to which all private consideration must give way. The following persons are exempted from being impressed:—Apprentices for three years; the master, mate, carpenter, and one men for every 100 tons, of vessels employed in the coal trade; all under 18 years of age, and above 55; foreigners in merchant ships and privateers; landmen betaking themselves to sea for two years; seamen in the Greenland fishery, and harpooners, employed, during the interval of the fishing season, in the coal trade, and giving security to go to the fishing next season.

IMPRESSION, is applied to a species of objects which are supposed to make some mark or impression on the senses, the mind, and the memory. The Peripatetics assert, that bodies emit species resembling them, which are conveyed to the common *senserium*, and they are rendered intelligible by the active intellect; and when thus spiritualized, are called expressions, or express species, as being expressed from the others.

Impression, also denotes the edition of a book, regarding the mechanical part only; whereas, besides this, it takes the care of the editor, who corrected or augmented the copy, adding notes, &c. to render the work more useful.

IMPRISONMENT, the state of a person restrained of his liberty, and detained under the custody of another. No person is to be imprisoned but as the law directs, either by the command or order of a court of record, or by lawful warrant; or the king's process, on which one may be lawfully detained. And at common law, a person could not be imprisoned unless he were guilty of some force and violence, for which his body was subject to imprisonment, as one of the highest executions. Where the law gives power to imprison, in such cases it is justifiable, provided he that does it in pursuance of a statute, exactly pursues the statute in the manner of doing it: for otherwise it will be deemed false imprisonment, and of consequence it is unjustifiable. Every warrant of commitment for imprisonment ought to run, "till delivered by due course of law," and "not until further order;" which has been held ill: and thus it also is, where one is imprisoned on a warrant not mentioning any cause for which he is committed. But an act of this kind can rarely occur in Britain.

False **Imprisonment**. Every confinement of the person is an imprisonment, whether it be in common prison, or in a private house, or in the stocks, or even by forcibly detaining one in the public streets. Unlawful or false imprisonment, consists in such confinement or detention without sufficient authority: which authority may arise either from some process from the courts of justice; or from some warrant from a legal power to commit, under his hand and seal, and expressing the cause of such commitment; or from some other special cause warranted, for the necessity of the thing, either by common law or act of parliament; such as the arresting of a felon by a private person without warrant, the impressing of mariners for the public service, or the apprehending of waggoners for misbehaviour in the public highways. False imprisonment also may arise by executing a lawful warrant or process at an unlawful time, as on a Sunday; or in a place privileged from arrests, as in the verge of the king's court. This is the injury. The remedy is of two sorts, the one removing the injury, the other making satisfaction for it. The satisfactory remedy for this injury of false imprisonment, which is generally and almost unavoidably accompanied with a charge of assault and battery also, is, that the party therein shall recover damages for the injuries he has received; and also the defendant is, as for all other injuries committed with force, or *vi et armis*, liable to pay a fine to the king for the violation of the public peace.

IMPROPRIATION, is when a benefice ecclesiastical is in the hands of a layman, and Appropriation when in the hands of a bishop, college, or religious house. It is said there are 3845 impropriations in England.

IMPULSE, a momentary action, or force, such as that which arises from the sudden explosion of fired gunpowder, or the momentum of a moving body.

IMPULSION, in Mechanical philosophy, a term employed for expressing a supposed peculiar exertion of the powers of body, by which a moving body changes the motion of another body by hitting or striking it. The plainest case of this action is, when a body in motion hits another body at rest, and puts it in motion by the stroke. The body thus put in motion is said to be *impelled* by the other; and this way of producing motion is called impulsion, to distinguish it from pression, pushing, or protrusion, by which we push a body from its place without striking it. The term has been gradually extended to every change of motion occasioned by the collision of bodies. *See* Mechanics.

IMPULSIVE, relating to impulse.

IMPUTATION, in general, the charging something to the account of one which belonged to another; thus the assertors of original sin maintain, that Adam's sin is imputed to all his posterity. In the same sense, the righteousness and merits of Christ are imputed to true believers.

INACCESSIBLE, that which cannot be approached; thus we say inaccessible *height, distance, &c.* *See* Accessible Height and Distance.

INALIENABLE, that which cannot be legally alienated or made over to another: thus the dominions of the king, the revenues of the church, the estates of a minor, &c. are inalienable, otherwise than with a reserve of the right of redemption.

INARCHING, in Gardening, a method of grafting, usually called grafting by approach.

INAUGURATION, the coronation of an emperor or king, or the consecration of a prelate; so called from the ceremonies used by the Romans, when they were received into the college of augurs.

IN AUTRE DROIT, in another's right, is where executors or administrators sue for debt or duty, &c. of the testator or intestate.

INCANTATION, denotes certain ceremonies, accompanied with a formula of words, and supposed to be capable of raising devils, spirits, &c. *See* Charm, &c.

INCAPACITY, in the Canon law, is of two kinds. 1. The want of dispensation for age in a minor, for legitimation in a bastard, and the like: this renders the provision of a benefice void in its original. 2. Crimes and heinous offences, which annul provisions at first valid.

INCARNATION, in Theology, denotes the act whereby the Son of God assumed the human nature; or the mystery by which Jesus Christ, the eternal Word, was made man, in order to accomplish the work of our salvation. The era used among Christians, whence they number their years, is the time of the incarnation, that is, of Christ's conception in the virgin's womb.

INCENDIARY, in Law, is applied to one who is guilty of maliciously setting fire to another's dwelling-house; and all houses that are parcel thereof, though not contiguous to it, or under the same roof, as barns and stables. A bare intent or attempt to do this, by actually setting fire to a house, unless it absolutely burns, does not fall within the description of *incendit et consumpsit*. But the burning and consuming of any part is sufficient, though the fire be afterwards extinguished. It must also be a malicious burning; otherwise it is only a trespass. This offence is called *arson* in our law.

INCENSE, or Frankincense, in the *Materia Medica*, &c. a dry resinous substance, known among authors by the names *thus* and *olibanum*. Incense is a rich odour, with which the Pagans and the Roman Catholics still perfume their temples altars, &c. The words come from the Latin *incensum*, *q. d.* burnt; as taking the effect for the thing itself. The burning of incense made part of the daily service of the ancient Jewish church. The priests drew lots to know who should offer it; the destined person took a large silver dish, in which was a censer full of incense; and being accompanied by another priest carrying some live coals from the altar, went into the temple. There, in order to give notice to the people, they struck upon an instrument of brass, placed between the temple and the altar; and being returned to the altar, he who brought the fire to the altar left it there, and went away. Then the offerer of incense having said a prayer or two, waited the signal, which was the burning of the holocaust; immediately upon which he set fire to the incense, the whole multitude continuing all the time in prayer. The quantity of incense offered each day was half a pound in the morning, and as much at night.

The reason of this continual burning of incense might be, that the multitude of victims that were continually offered up, would have made the temple smell like a slaughter-house, and consequently have inspired the comers rather with disgust and aversion, than awe and reverence, had it not been overpowered by the agreeable fragrance of those perfumes.

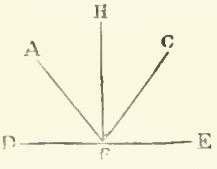
INCEST, is the carnal knowledge of persons within the Levitical degrees of kindred.

INCH, a measure of length; being the 12th part of a foot, and equal to three barleycorns in length.

INCHASING. *See* Enchasing.

INCIDENCE, in Mechanics and Optics, is used to denote the direction in which a body or ray of light strikes another body, and is otherwise called inclination. In moving bodies, their incidence is said to be perpendicular or oblique, according as their lines of motion make a straight line or an angle at the point of contact.

Angle of Incidence, generally denotes the angle formed by the line of incidence and a line drawn from the point of contact perpendicular to the plane or surface on which the body or ray impinges. Thus if a body A impignes on the plane D E, at the point B, and the perpendicular B H be drawn, then the angle A B H is generally called the angle of incidence, and A B D the angle of inclination. Dr. Wallis, however, and some other old authors, call the angle A B D the angle of incidence, being that included between the line of incidence, and the surfaces of the plane on which the body impinges; the complement of that angle, as A B H, being by these writers called the angle of inclination. Other distinctions are made by Wolfius in the denomination of these angles, but they are of very trifling importance.



1. It is demonstrated by writers on optics, that the angle of incidence A B H, is always equal to the angle of reflectio H B C; or the angle A B D = angle C B E. *See* Reflection. 2. It has also been demonstrated from experiment, that the angles of incidence and refraction are to each other, accurately or very nearly, in a given ratio. 3. That from air to glass the sine of the angle of incidence is to the sine of the refracted angle, as 300 to 193, or nearly as 14 to 9; and on the contrary

from glass to air, the angle of incidence to that of refraction, is as 193 to 300, or nearly as 9 to 14. See Refraction.

Axis of Incidence, is the line B H in the preceding figure.

Line of Incidence, or Incident *Ray*, in *Catoptrics* and *Dioptrics*, is the line of direction in which a ray is propagated, as the line A B, in the above figure; this is also called the Incident *Ray*.

Point of Incidence, is the point where the incident ray meets the reflecting or refracting body; such is the point B.

INCIDENT, signifies a thing necessarily depending upon another as more principal.

INCLINATION, denotes the mutual approach or tendency of two bodies, lines, or planes, towards each other, so that the lines of their direction make at the point of contact any angle of greater or less magnitude.

Inclination of a *Right Line* to a *Plane*, is the acute angle which such a right line makes with another right line, drawn in the plane through the point where the inclined line intersects it, and through the point, where it is also cut by a perpendicular drawn from any point of the inclined lines.

Inclination of *Meridians*, in Dialling, the angle that the hour line on the globe, which is perpendicular to the dial plane, makes with the meridian.

Inclination of an *Incident Ray*, otherwise called the angle of Inclination. See *Angle* of Incidence.

Inclination of a *Reflected Ray*, is the angle which a ray after refraction makes with the axis of inclination.

Inclination of the *Axis of the Earth*, is the angle which it makes with the plane of the ecliptic; or the angle between the planes of the equator and ecliptic.

Inclination of the *Magnetic Needle*. See Dipping *Needle*.

Inclination of a *Planet*, is an arc or angle comprehended between the ecliptic, and the plane of a planet in its orbit.

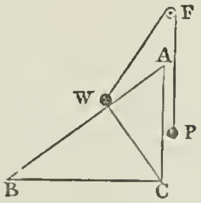
Inclination of a *Plane*, in Dialling, is the arc of a vertical circle perpendicular both to the plane and to the horizon, and intercepted between them.

Inclination of two *Planes*, is the acute angle made by two lines drawn one in each plane, through a common point of section, and perpendicular to the same common section.

Inclination, *Angle* of, in Optics, is the same that is otherwise called the angle of Incidence.

INCLINED Plane, in Mechanics, as the name imports, is a plane which forms with an horizontal plane any angle whatever, forming one of the simple mechanical powers. The inclination of the plane is measured by the angle formed by two lines drawn from the sloping and the horizontal plane. perpendicular to their common intersection. The principal mechanical properties of the inclined plane are as follows; *viz.*

1. When a body is sustained upon an inclined plane, the sustaining power, or weight, will be to the weight of the body, as the sine of the plane's inclination is to the sine of the angle which the direction of the power makes with a perpendicular to the plane.



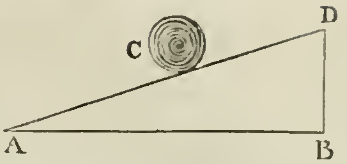
Thus, let A B be an inclined plane, W a weight sustained upon that plane by the power, W F the line of the direction of the power, and W C a perpendicular to the plane A B: then

$P : W :: \text{sine} \angle ABC \ \text{sine} \angle FWC$.

When W F coincides with W A, that is, when the power acts in a direction parallel to B A, then the proportion becomes P : W :: sine of plane's inclination : radius; or, which is the same thing, $P : W :: AC : BA$; that is,

the power : weight :: height of the plane : its length.

When a plane is inclined to the horizon one-third of its whole length, any body will be kept from rolling down that plane, by a power equal to a third part of the weight of the body. If D A be six feet and B D two feet: then if C be six pounds, a power of two pounds will support it: if the height of the plane be equal to half its length, a power equal to half the weight of the body will support it: but a plane perpendicularly situated, ought not to come under the denomination of this article, because the plane in such a direction contributes nothing to the support or hinderance of the falling body, which descends with its whole force of gravity, unless prevented by a power equal to its whole weight.

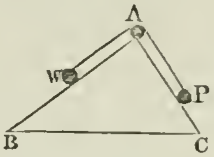


It is obvious from this illustration, that the less the angle of elevation, or the gentler the ascent is, the greater will be the weight which a given power can draw up; for the steeper the inclined plane is, the less does it support of the weight; and the greater the tendency which the weight has to roll, consequently the more difficult for the power to support it: hence the advantage gained by this mechanical power is as great as its length (A D) exceeds its perpendicular height (B D).

2. If two bodies keep each other in equilibrio, by a string passing over the vertex of two different inclined planes, the weights of the bodies will be to each other as the sines of the angles of inclination of the opposite planes.

That is, $W : P :: \text{sine} \angle BCA : \text{sine} \angle ABC$;

or $W : P :: BA : AC$;

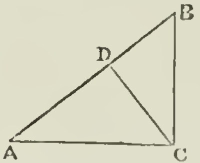


because the sides of triangles are to each other as the sines of their opposite angles.

The velocity acquired by a body descending by the action of gravity down an inclined plane, is to the velocity of a body falling perpendicularly during the same time, as the height of the plane is to the length.

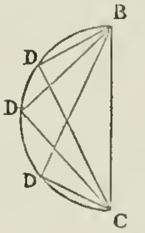
The force whereby a body descends down an inclined plane is to the absolute force of gravity, as the height of the plane to its length; which being a constant ratio for the same plane, it follows that the force whereby the body descends is uniform, and consequently that it will produce a uniformly accelerated motion. Therefore all the laws laid down under the article Acceleration have equal place with regard to bodies on inclined planes, by merely substituting for gravity the product of gravity into the sine of the plane's inclination. The same is also true with regard to the retardation in bodies projected up any given inclined planes.

3. Hence again the space descended down inclined planes is to the space perpendicularly described in the same time, as the height of the plane is to its length.



Consequently the velocities acquired, and the spaces descended by bodies down different inclined planes in the same time, are as the sines of the plane's elevation.

If A B be any inclined plane, and D C be drawn perpendicular to A B; then while a body falls freely through the perpendicular B C, another body will in the same time descend down the part of the plane B D.



Hence we deduce the following curious property of bodies descending down inclined planes. In any right-angled triangle having its hypothenuse B C perpendicular to the horizon, a body will descend down any of its three sides, B D, B C, D C, in the same time. And therefore, if on the diameter B C a semicircle be described, the time of descending down any chords B D, B D′, B D″, &c. D C, D′ C, D″ C, &c. will be all equal, and each equal to the time of falling freely through the diameter B C.

The time of descending down an inclined plane, is to the time in falling through its perpendicular height, as the length of the plane is to its height. Consequently the times of descending down different planes of the same height are as the lengths of the planes.

A body acquires the same velocity in descending down an inclined plane, as in falling perpendicularly through the height of the plane. Hence the velocities are always the same in planes of the same altitude, whatever may be their degrees of nclination.

We may form an inclined plane by placing boards of earth or other materials in a sloping direction. The sides of hills, wedges, screws, jacks, &c. are all used in mechanics on the same principle; and their power depends on the proportion between the height actually attained, and the length of the plane moved over.

INCLINERS, or Inclining Dials, are such as are drawn on planes that are not perpendicular to the horizon.

INCLOSURES. Any person who shall wilfully or maliciously destroy or damage any fence made for enclosing any common waste, or other lands, in pursuance of any act of parliment, shall be transported for seven years.

INCOMBUSTIBLE Cloth. *See* Asbestos. On this, Cronstadt observes, that the natural stone of the asbesti is in proportion to their economical use, both being very inconsiderable. It is an old tradition, that in former ages they made clothes of the fibrous asbesti, which is said to be composed of the word *byssus;* but it is not very probable, since, if one may conclude from some trifles now made of it, as bags, ribbons, and other things, such a dress could neither have an agreeable appearance, nor be of any conveniency or advantage. It is more probable, that the Scythians dressed their dead bodies which were to be burned, in a cloth manufactured of this stone; and this perhaps has occasioned the above fable. Mr. Magellan confirms this opinion of Cronstadt's, and informs us, that some of the Romans also enclosed dead bodies in cloth of this kind. In the year 1756 or 1757, he tells us, that he saw a large piece of asbestos cloth found in a stone tomb, with the ashes of a Roman, as appeared by the epitaph. It was kept with the tomb also, if our author remembers rightly, in the right wing of the Vatican library at Rome. The under librarian, in order to shew that it was incombustible, lighted a candle, and let some drops of wax fall on the cloth, which he set on fire with a candle in his presence, without any detriment to the cloth. Its texture was coarse, but much softer than he could have expected.

There are many substances of vegetable origin, of common domestic use, which it would be of the utmost importance to render less liable to be set on fire, if they could not be rendered incombustible altogether. If muslins, and other cotton goods, be dipped in a weak solution of potass, they will be less liable to burn; but the objection is, that by the attraction of moisture from the atmosphere, they would be less agreeable. It has also been found, that solutions of muriate, sulphate, phosphate, and borate of ammonia, with borax, render cloth incombustible. Acidulous phosphate of lime has the same effect. Linen, muslin, wood, or paper, dipped in a solution of this salt, of the specific gravity of 1·26 to 1·30, are completely incombustible and may be charred by intense heat, but will not burn. Several experiments were made at Venice in 1807, by a Monsieur Gonzatti, with a liquor, which being thrown in a small quantity on any combustible article on fire, has immediately extinguished it. A few drops only, being thrown on a quantity of resin and oil, which was burning, the fire was immediately extinguished; and it was said that a layer of this composition being spread upon any wood work, it was entirely safe from combustion. The inventor would not make known the preparation of his composition, but it was very probably a solution of alum, potass, and vitriol.

INCOMMENSURABLE Lines, are such as have no common measure. The diagonal and side of a square are incommensurable, being to each other as $\sqrt{2}$ to 1; and consequently whatever number of parts the side of the square may be divided into, the hypothenuse will not be made up of any exact number of such parts.

Incommensurable *Numbers*, or *Numbers Prime to each other*, are those which have no integral common measure greater than unity.

If numbers be incommensurable with each other, they are incommensurable also in power, that is, no powers of such numbers can be incommensurable with each other.

INCOMPLETE, in Botany, a term used to denote the sixteenth class of the Linnæan "methodus calycina," consisting of plants whose flowers want either the calyx or petals.

INCOMPOSITE Numbers, the same as Prime *Numbers.*

INCORPORATION, *Power of.* To the erection of any corporation the king's consent is necessary, either impliedly or expressly given. The methods by which the king's consent is expressly given to the formation of a body politic, are either by act of parliament or charter.

INCREMENT, in the doctrine of Increments, or Finite Differences, is the finite increase of a variable quantity. Dr. Brooke Taylor, to whom we are indebted for this theory, denoted his increments by a dot under the variable quantity: thus the increment of x was denoted by $\underset{\cdot}{x}$; Emmerson also employs the same notation; others have used a small accent, as x', or thus x. —Mr. Nicole denotes the increment of x, or any variable,' by n; but Euler, who seems to have given a permanent form to this branch of analysis, employs the character Δx; thus the increment of $x = \Delta x$, increment of $y = \Delta y$, &c.

INCUBUS, *Nightmare*, a disease consisting in an oppression of the breast so very violent, that the patient cannot speak or even breathe. The word is derived from the Latin *incubare*, to "lie down" on any thing and press it. The Greeks call it εφσαλης, *q. d.* saltator, "leaper," or one that rusheth on a person. In this disease the senses are not quite lost, but drowned and astonished, as is the understanding and imagination, so that the patient seems to think some huge weight thrown on him ready to strangle him. Children are very liable to this distemper; so are fat people, and men of much study and application of mind—because the stomach, in all these, finds some difficulty in digestion.

INCUMBENT, a clerk or minister who is resident on his benefice; he is called incumbent, because he does, or at least ought to, bend his whole study to discharge the cure of his church.

INCURVATION of the Rays of Light, their bending out of the rectilinear or straight course, occasioned by refraction.

INDEFINITE, that which is without any assigned limits; thus we say an indefinite line, meaning a line of any length. Some authors use the word indefinite nearly in the same sense as we commonly attach to the term infinite. According to these, an indefinite line is that which is without termination; the former, however, is the sense in which it is commonly employed by modern mathematicians.

Indefinite, in Grammar, is understood of nouns, pronouns, verbs, participles, articles, &c. which are left in an uncertain indeterminate sense.

INDELIBLE, something that cannot be cancelled or effaced, as indelible ink. *See* Ink.

INDEMNITY, in Law, the saving harmless; or a writing to secure one from all damage and danger that may ensue from any act.

INDENTED, in Heraldry, is when the outline of an ordinary is notched like the teeth of a saw.

INDENTURE, in Law, a writing which comprises some contract between two at least; being indented at top, answerable to another part which has the same contents. *See* Deed.

INDEPENDENTS, or Congregationalists, a sect of protestant Dissenters, so called from their founder, maintaining that all Christian congregations are so many independent religious societies, having a right to be governed by their own laws, without being subject to any further or foreign jurisdiction.

INDETERMINATE, is nearly the same as *Indefinite*, the former being applied to numbers, as the latter is to geometrical lines, surfaces, &c. with this difference, however, that the word indeterminate commonly implies that number or quantity whose value cannot be assigned; and the former, that which may be of any magnitude.

Indeterminate *Analysis*, is a very interesting branch of algebra, in which there are always given a greater number of unknown quantities than there are independent equations, by which means the number of solutions is indefinite, though it commonly happens that certain restrictions are introduced, such as requiring integral or rational numbers, which frequently limit the number of solutions, and even in some cases render the problem impossible.

INDETERMINATE Problem, in Algebra, is that which admits of many different solutions and answers, called also an unlimited problem.

INDEX, in Arithmetic and Algebra, is the same as exponent.

Index of a *Logarithm*, called otherwise the *Characteristic*, is the integral part which precedes the logarithm, and is always one less than the number of integral figures in the given number. Or otherwise, the index is always equal to the number of places that the unit's place of the proposed number is from the first effective figure, and is accounted positive when the first figure is to the left of the unit's place, and negative when it is to the right.

Index of a Globe, is a small hand fitted to the extremity of the north pole, which turning round with it points out the time upon the hour circle.

INDIA Rubber. *See* Caoutchouc.

INDICATIVE, in Grammar, the first mood, or manner, of conjugating a verb, by which we simply affirm, deny, or ask something.

INDICTION, or Roman Indiction, (from *indico, to proclaim,*) in Chronology, is a term used for a sort of epocha amongst the ancient Romans; the origin or commencement of which is not distinctly known. The Roman indiction consists of a cycle of fifteen years, and when expired begins anew, and goes on again in the same order without any dependence on the motions of the heavenly bodies. The popes since the time of Charlemagne have dated their acts by the year of indiction, which was fixed on the first of January, A. D. 313. At the time of their reformation of the calendar, the year 1582 was reckoned the 10th year of the indiction. Now this date when divided by 15 leaves a remainder 7, that is, 3 less than the indiction, and the same must necessarily be the case in all subsequent dates; therefore to find the indiction for any year, divide the date by 15, and add 3 to the remainder, which will be the indiction; thus in the present year 1826, we have $\frac{1826}{15} = 121$, and remainder 14; consequently $14 + 3 = 17$, the indiction.

INDICTMENT, is a written accusation of one or more persons, of a crime or misdemeanor, preferred to, and presented on oath by, a grand jury. An indictment may be found on the oath of one witness, unless it be for high treason, which requires two witnesses, and unless in any instance it is otherwise specially directed by acts of parliament. The sheriff of every county returns to every session of the peace, and every commission of oyer and terminer, and of general gaol delivery, twenty-four good and lawful men of the county, some out of every hundred, to inquire, present, and do all those things, which on the part of the king shall be commanded therein. As many as appear are sworn of the grand jury, to the amount of twelve at the least, and not more than twenty-three. Being previously instructed in the articles of their inquiry, by a charge from the judge, they receive indictments preferred to them in the name of the king, but at the suit of any private prosecutor; and they only hear evidence on behalf of the prosecution. They may not find part of an indictment true and part false, but must either find a true bill or an ignoramus for the whole. All capital crimes whatsoever, and all kinds of inferior crimes which are of a public nature, may be indicted, but no injuries of a private nature, unless they in some degree concern the king. And generally, where a statute prohibits a matter of public grievance, or commands a matter of public convenience, every disobedience to it is punishable, not only at the suit of the party grieved, but also by indictment. Yet if the party offending have been fined in any action brought by the party, such fine is a good bar to the indictment. Several offenders committing the same offence may be joined in one indictment. No indictment for high treason, or misprision thereof, (except indictments for counterfeiting the king's coin, seal, sign, or signet,) shall be quashed for mis-reciting, misspelling, &c. unless exception concerning the same be taken before any evidence given in open court, on such indictment. An indictment accusing a man in general terms, without ascertaining the particular fact laid to his charge, is insufficient; nor can it be good, without expressly shewing some place where the offence was committed.

There are several words of art, which the law has appropriated for the description of an offence, which no circumlocution will supply; as feloniously, in the indictment of any felony; burglariously, in an indictment of burglary. And an indictment on the black act for shooting at any person, must charge that the offence was done wilfully and maliciously.

No clerk of assize, clerk of the peace, or other person, is allowed to take any money of any person bound over to give evidence against a traitor or felon, for the discharge of his recognizance, nor more than two shillings for drawing any bill of indictment against any such felon, on pain of five pounds to the party grieved, with full costs. Every person charged with felony or other crime, who on his trial is acquitted, or against whom no indictment is found by the grand jury, or who is discharged by proclamation for want of prosecution, should be immediately set at large in open court, without payment of any fee to the sheriff or gaoler. This however is usually deferred till after the assizes or sessions are over, when the judge or justices proceed to the gaol delivery.

Upon a certificate of an indictment being found, for an assault or other misdemeanor, and much more for a felony, a warrant is issued, on the application of the prosecutor, to take the party into custody, and he may be held to bail by a justice of the peace, or a judge. This was not formerly the practice upon indictments, but an action cannot be brought by the person acquitted, against the prosecutor of the indictment, without obtaining a copy of the record of his indictment and acquittal; which, in prosecutions for felony, it is not usual to grant, if there be the least probable cause to found such prosecution upon. But an action on the case, for a malicious prosecution, may be founded on such an indictment whereon no acquittal can be, as, if it be rejected by the grand jury, or be *coram non judice*, or be insufficiently drawn; for it is not the danger of the plaintiff, but the scandal, vexation, and expense, upon which this action is founded. However, any probable cause for preferring it is sufficient to justify the defendant, provided it do not appear that the prosecution was malicious.

INDIGO, a dye prepared from the leaves and small branches of the *Indigofera tinctoria*. There are two kinds, the true and the bastard. The produce of the first is sold at a higher price, on account of its superiority, but that of the other is heavier. The first will grow in many soils; the second succeeds best in those most exposed to rain; both are liable to great accidents Sometimes the plant becomes dry, and is destroyed by an insect frequently found on it; at other times the leaves are devoured in the space of twenty-four hours by caterpillars. It ought to be gathered in with great precaution, for fear of shaking off the farina that lies on the leaves, and is very valuable. When gathered, it is thrown into the steeping-vat, which is a large tub filled with water. Here it undergoes a fermentation, which in twenty-four hours, at farthest, is completed. A cock is then turned to let the water (which is impregnated with a very subtile earth, constituting the blue substance) run into the second tub, called the mortar or pounding tub, where it is forcibly agitated with wooden buckets, full of holes, and fixed to a long handle. When the workmen perceive that the coloured particles collect by separating from the rest of the liquor, they leave off shaking the buckets, in order to allow time to the blue dregs to precipitate to the bottom, where they are left to settle till the water is quite clear. Holes made in the tub at different heights are then opened one after another, and this useless water is let out. The blue dregs remaining at the bottom having acquired the consistence of a thick muddy liquid, cocks are opened, which draw it off into the settler. It is thence poured into linen bags, and when the water has sufficiently drained from it, it is formed into small lumps and dried in the shade. Indigo is used in washing, to give a bluish colour to linen: painters also employ it in their water colours; and dyers cannot make fine blue without it.

Indigo may be obtained from the nerium tinctorium, and the isatis tinctoria, or woad; a plant cultivated and even found wild in England. When arrived at maturity this plant is cut down, washed, dried hastily in the sun, ground in a mill, placed in heaps, and allowed to ferment for a fortnight. It is then well mixed, and made up into balls, which are piled upon each other, and exposed to the wind and sun. In this state they become hot, and exhale a putrid ammoniacal smell. When the fermentation has continued for a sufficient time, the woad is allowed to fall to a coarse powder.

The solution of indigo is well known in this country by the name of liquid blue, or sulphate of indigo. While concentrated, it is opaque and black; but when diluted, it assumes a fine deep colour; and its intensity is such, that a single drop of the concentrated sulphate is sufficient to give a blue colour to many pounds of water. Bergman ascertained the effect of different re-agents on this solution. Dropt into sulphurous acid, the colour was at first blue, then green, and very speedily destroyed. In vinegar it becomes green, and in a few weeks the colour disappears. In weak potash it becomes green, and then colourless. In weak carbonate of potash there are the same changes, but more slowly. In ammonia and its carbonate the colour becomes green, and then disappears. In a solution of sugar it became green, and at last yellowish. In sulphate of iron the colour became green, and in three weeks disappeared. In the sulphurets the colour was destroyed in a few hours. Realgar, white oxide of arsenic, and orpiment, produced no change. Black oxide of manganese destroyed the colour completely.

INDIVIDUAL, in Logic, a particular being of any species, or that which cannot be divided into two or more beings equal or alike.

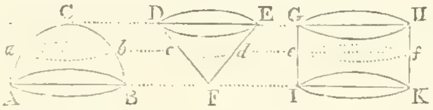
INDIVISIBLE, among metaphysicians, a thing is said to be indivisibly absolute, absolutely indivisible, that is, a simple being, and consists of no parts into which it may be divided.

INDIVISIBLES, in Geometry, are those small elements or principles into which any body or figure may be resolved.

According to the principles of this method, a line is said to consist of a number of contiguous points, or surface of lines, and a solid of surfaces; and because each of these elements is supposed indivisible, if in any figure a line be drawn through the elements perpendicularly, the number of points in that line will be the same as the number of elements.

Hence it follows that a parallelogram, prism, or cylinder, is resolvable into elements, or indivisibles, all equal to each other, parallel and like to the base; and a triangle, into lines parallel to the base, but decreasing from the base upwards in an arithmetical progression; so also the circles which constitute the parabolic conoid, and the several concentric circumferences which constitute a circle, and the successive circumferences which make up the surface of a right cone, all decrease according to the same law.

The great facility attending the method of indivisibles is very obvious in the demonstration of the celebrated theorem of Archimedes, *viz.* "Every sphere is two-thirds of its circumscribing cylinder," the principles of which are as follows.



Let A C B, D E F, and G H I K, represent a hemisphere, inverted cone, and cylinder, having equal bases and altitudes, and all standing on the common base line A F K. Then it is easily demonstrated, that if any sections be made in these solids, by a plane passing parallel to the common base, that the section *e f* of the cylinder is equal to the two sections *a b*, *c d*, of the hemisphere and cone; and as this is the case in every parallel position of the cutting plane, it follows that the sum of all the sections of the cylinder, is equal to the sum of all the sections of the hemisphere and cone; and hence it is inferred, that the solidity of the cylinder is equal to the solidity of the hemisphere and cone. But the cone is a third part of the cylinder, having the same base and altitude, hence the hemisphere is equal to the remaining two-thirds.

INDORSEMENT, in Law, signifies any thing written upon the back of a deed or other instrument. On sealing of a bond, the condition of the bond may be indorsed. In order to the executing a justice of the peace's warrant in another county, it must be indorsed by some justice in such other county. It is customary also to indorse the receipt of the consideration-money upon a deed. Bills *of Exchange* are indorsed, and every indorser is liable to the full amount of the bill he puts his name on.

INDUCTION, in Law, is putting a clerk or clergyman in possession of a benefice or living to which he is collated or presented. *See* the article Parson. Induction is performed by a mandate from the bishop to the archdeacon, who usually issues out a precept to other clergymen to perform it for him. It is done by giving the clerk corporal possession of the church, as by holding the ring of the door, tolling a bell, or the like; and is a form required by law, with intent to give all the parishioners due notice and sufficient certainty of their new minister, to whom their tithes are to be paid. This, therefore, is the investure of the temporal part of the benefice, as institution is of the spiritual. And when a clerk is thus presented, instituted, and inducted into a rectory, he is then, and not before, in full and complete possession; and is called in law *persona impersonata*, or parson impersonnee.

INDUCTION, is a term used by mathematicians to denote those cases in which the generality of any law, or form, is inferred, from observing it to have obtained in several cases. Such inductions, however, are very deceptive, and ought to be admitted with the greatest caution, as there are numerous cases in which a law may obtain for a considerable way, and ultimately fail when its uniformity is supposed certain. A remarkable instance of the failure of induction appears in many of those formulæ which have been given for prime numbers. Thus the formulæ $x^2 + x + 41$, by making successively $x = 1, 2, 3, 4$, &c. will give a series, the first forty terms of which are prime numbers, whence one might be induced to conclude the law to be universal; it fails however in the very next case, the forty-first term being a composite number.

INDULGENCES, in the Romish church, are a remission of the punishment due to sins, granted by the church, and supposed to save the sinner from purgatory.

According to the doctrine of the Romish church, all the good works of the saints, over and above those which were necessary towards their own justification, are deposited, together with the infinite merits of Jesus Christ, in one inexhaustible treasury. The keys of this were committed to St. Peter, and to his successors the popes, who may open it at pleasure, and by transferring a portion of this superabundant merit to any particular person, for a sum of money, may convey to him either the pardon of his own sins, or release for any one in whom he is interested, from the pains of purgatory. Such indulgencies were first invented in the 11th century, by Urban II. as a recompense for those who went in person upon the glorious enterprise of conquering the Holy Land. They were afterwards granted to those who hired a soldier for that purpose; and in process of time were bestowed on such as gave money for accomplishing any pious work enjoined by the pope. The terms in which the retailers of indulgences described their benefits, and the necessity of purchasing them, are so extravagant, that they appear almost incredible. If any man (said they) purchases letters of indulgence, his soul may rest secure with respect to its salvation. The souls confined in purgatory, for whose redemption indulgences are purchased, as soon as the money tinkles in the chest, instantly escape from that place of torment, and ascend into heaven. That the efficacy of indulgences was so great, that the most heinous sins, even if one should violate (which was impossible) the mother of God, would be remitted and expiated by them, and the person be freed both from punishment and guilt. That this was the unspeakable gift of God, in order to reconcile man to himself. That the cross erected by the preachers of indulgences was equally efficacious with the cross of Christ itself. "Lo! the heavens are open; if you enter not now, when will you enter? For twelve pence you may redeem the soul of your father out of purgatory; and are you so ungrateful, that you will not rescue your parent from torment? If you had but one coat, you ought to strip yourself instantly, and sell it, in order to purchase such benefits," &c.

In the last year, (1825) the Pope, Leo XII. issued a Bull of Indication, appointing a jubilee for the whole of the Catholic church, and to continue through the whole of the year, during which period his holiness mercifully granted and imparted the most plenary and complete indulgence, remission, and pardon of all their sins, to all the faithful of Christ of both sexes.

INDURATED Mud. The American volcanoes discharge torrents of mud, which seem to be strongly impregnated with iron. It has been said that similar torrents have issued from Etna and Vesuvius, but it is supposed that the appearances have arisen from melted snow. The grand volcanoes of Cotopaxi, Tungarunga, and Sangay, in South America, eject prodigious quantities of mud, and what is more remarkable, prodigious quantities of fish, so as to infect the air with putrefaction. These fish appear to be little injured, and are the same with those found in the rivulets at the bottom of the volcanoes, being a pimelodes silurus from two to four inches in length. These muddy eruptions become fertile clay, and are very productive. Ferrara gives an interesting account of a muddy eruption at Maculaba in Sicily. Sometimes this phenomenon appears with immense force. The inhabitants of the neighbourhood still (1826) remember with terror the eruption of 1777, one of the most violent yet known.

INEBRIANTS, are defined to be such things as affect the nerves in a particular and agreeable manner, and through them alter and disturb the functions of the mind. They are properly divided into native and artificial; the former chiefly in use among the oriental and other nations, the latter principally throughout Europe.

Natural INEBRIANTS, are, 1. Opium, in use all over the east, and of which the Turks, through custom, swallow a drachm. 2. Perganum harmala, Syrian rue. The seeds are sold in Turkey for this purpose; and with these, as Bellonius relates, the Turkish emperor Solyman kept himself intoxicated. 3. Maslac of the Turks, or bangue of the Persians, prepared from the dust of the male-flower of hemp, or from the leaves. 4. Bangue of the Indians, from the leaves of the hibiscus sabdariffa. 5. Seeds of various species of the datura, or thorn apple. 6. Tinang, or betel of the Indians. 7. Roots of the black henbane. 8. The hyoscyamus physaloides. 9. Berries of the deadly nightshade. 10. Leaves of milfoil are used by the Dalekarlians to render their beer intoxicating. 11. Tobacco, and several others less material are mentioned; such as clay, saffron, and darnel.

Artificial INEBRIANTS, are fermented liquors from farinaceous seeds; wines and spirits drawn by distillation. With these is ranked the nectar of the gods, and the anodyne medicine of Homer, commonly called *nepenthes;* and the spells by which Medea and Circe produced their enchantments.

INERTIA OF MATTER, in Philosophy, a passive principle, by which bodies persist in a state of motion or rest, receive motion in proportion to the force impressing them, and resist as much as they are resisted. *See* MECHANICS.

INFALLIBLE, something that cannot err, or be deceived. One of the great controversies between the Protestants and Papists, is the infallibility which the latter attribute to the pope; though in fact, they themselves are not agreed on that head, some placing this pretended infallibility in the pope and a general council.

INFAMY, in Law, is a term which extends to perjury, gross cheats, &c. by which a person is rendered incapable of being a witness or juror, even though he is pardoned for his crimes.

INFANCY, the first stage of life; in a medical and political view, extending from birth to about the seventh year.

Treatment of Infants in Health.—The two primary objects of attention on the birth of an infant are warmth and cleanliness. There is generally too much eagerness in putting the child to the breast; who is often worried to suck before he becomes actuated by the instinctive principle of nature, or before the mother finds her breasts sufficiently filled with milk to satisfy his desire. It is generally about the third day after child-bed, that both are fully prepared. It is the duty of every mother to suckle her child. When in consequence of suppression of milk, and extreme delicacy, or disease of constitution, hired nurses must be resorted to, the young and the healthy should be selected, with a full breast of milk, and that milk as nearly as may be the age of the foster-child. If a proper nurse cannot be procured, diluted cow's milk, intermixed with a small quantity of farinaceous food, will generally prove the most convenient nutriment. Cow's milk, however, is far less sweet than human, and hence the mixture now recommended should be enriched with some addition of sugar. The chief point of attention is, that the farinaceous matter, whether in the form of pap or gruel, be sufficiently dilute, and pressed through a fine strainer, to free it from lumps. Cordials, aperients, and opiates, should be avoided in a state of health.

The great and natural use of clothes is for the purpose of warmth, and the looser and softer the substance is by which this warmth is communicated, the better. Most of the deformities of children are occasioned by improprieties in their dress. An attempt to give neatness to the form renders pressure necessary; and where a part is weak, and the pressure greater than on the neighbouring parts, such part will naturally yield to the impulse, and deformity will ensue.

Sleep is at all times necessary to health, in infancy it is particularly so; for the stimuli of air and light alone are sufficient to exhaust the system in an hour or two. Nothing, however, can be more pernicious than the too common practice of administering cordials, opiates, &c., as often as the child seems restless.

The situation of infants requires at first air of a moderately warm temperature; after which they may be gradually inured to a colder atmosphere, without any danger to their health. Too much warmth, however, is as prejudicial as the opposite extreme, and the more to be dreaded, as every time they are brought to the open air, they are exposed to the danger of catching cold. But it is not merely a cold air that is to be avoided, it is the air that is confined, and at the same time loaded with moisture. A confined damp air is the cause of many of the diseases by which children are afflicted.

The nursery should be the largest and best aired room in the house. When children sleep in a cradle, they should not be wrapped up too closely. Neither when they are further grown, should more than one child sleep in the same bed. In short, the proper regulation is to keep the child as much as possible in one pure equal temperature, avoiding every thing that is damp or unwholesome.

The first exercise that children usually receive, is that of being dandled in the arm, or moved gently up and down, which tends much to assist digestion. Rubbing them with the hand is also highly useful.

As children increase in growth, their exercise should be proportionably augmented, and the nurse should endeavour to give them as much motion with her arm as possible.

As soon as a child is able to be put on its feet, it should be allowed to make use of them. Every member acquires strength in proportion as it is exercised; and children, by being accustomed to support themselves, will soon acquire strength for the purpose. Children also begin to use their feet by degrees; and by this gradual attempt, all danger of their legs becoming crooked, or unable to support the body, is avoided.

Among the poorer classes, it is very common to allow children to sit or lie in one posture for a length of time: this is a practice much to be condemned. By the want of exercise, the health of children suffers; a relaxation of the system ensues, and rickets and other diseases are induced.

The early and rigorous confinement of children at day schools, merits to be particularly reprobated. If sent early to school, the time of learning should never be long, and should be alternated with proper diversions and exercises suited to their period of life.

Exercise within doors is not sufficient to effect the good purposes derived from it in the open air. Children, instead of being checked in regard of wholesome play, should be at all times encouraged in it.

To uniform exercise, add the use of the cold bath. By general immersion, the body is braced and strengthened, the general circulation increased, and all stagnation in the smaller vessels prevented. The commencement of this practice early will be the means of preventing the appearance of many constitutional diseases. And even where it cannot be employed to its full extent, still the extremities should be every day bathed in cold water, and afterwards well dried, and the skin well rubbed. In this view, boys should be encouraged to learn and practise the salubrious and useful exercise of swimming.

INFANT, in Law, is a person under 21 years of age, whose capacities, incapacities, and privileges are various. 1. In criminal matters, the law of England does, in some cases, privilege an infant under the age of 21, as to common misdemeanors, so as to escape fine, imprisonment, and the like; and particularly in the cases of omission, as not repairing a bridge, or a highway, and other similar offences; for, not having the command of his fortune till the age of 21, he wants the capacity to do those things which the law requires. But where there is any notorious breach of the peace, a riot, battery, or the like, (which infants, when full grown, are at least as liable as others to commit,) for these, an infant above the age of 14 is equally liable to suffer as a person of the full age of 21. With regard to capital crimes, the law is still more minute and circumspect, distinguishing with greater nicety the several degrees of age and discretion. 2. In civil matters, the ages of male and female are different for different purposes. A male at 12 years old may take the oath of allegiance; at 14, is at the years of discretion, and therefore may consent or disagree to marriage, may choose his guardian, and if his discretion be actually proved, may make his testament of his personal estate; at 17 may be an executor; and at 21 is at his own disposal, and may alien his land, goods, and chattels. A female also, at 7 years of age, may be betrothed or given in marriage; at 9 is entitled to dower; at 12 is at the years of maturity, and therefore may consent or disagree to marriage, and, if proved to have sufficient discretion, may bequeath her personal estate; at 14 is at the years of legal discretion, and may choose a guardian; at 17 may be executrix; and at 21 may dispose of herself and her lands. So that full age, in male or female, is 21 years, which age is completed on the day preceding the anniversary of a person's birth; who till that time is an infant, and so styled in law. The very disabilities of infants are privileges, in order to secure them from hurting themselves by their own improvident acts. An infant cannot be sued but under the protection, and joining the name, of his guardian; for he is to defend him against all attacks, as well by law as otherwise: but he may sue either by his guardian, or prochein amie, his next friend, who is not his guardian. This prochein amie may be any person who will undertake the infant's cause; and it frequently happens, that an infant, by his prochein amie, institutes a suit in equity against a fraudulent guardian. With regard to estates and civil property, an infant hath many privileges. In general, an infant shall lose nothing by nonclaim, or neglect of demanding his right, nor shall any other *laches* or negligence be imputed to an infant, except in some very particular cases.

INFANTRY, in Military affairs, the whole body of foot-soldiers, whether independent companies or regiments. The word takes its origin from one of the infantas of Spain, who, finding that the army commanded by the king, her father, had been defeated by the Moors, assembled a body of foot-soldiers, and with them engaged and totally routed the enemy. In memory of this event, and to distinguish the foot-soldiers, who were not before held in much consideration, they received the name of infantry.

Heavy-armed INFANTRY, among the ancients, were such as wore a complete suit of armour, and engaged with broad shields and long spears. They were the flower and strength of the Grecian armies, and had the highest rank of military honour.

Light-armed INFANTRY, among the ancients, were designed for skirmishes, and for fighting at a distance. Their weapons were arrows, darts, or slings.

Light INFANTRY, among the moderns, have only been in use since the year 1656. They have no camp equipage to carry, and their arms and accoutrements are much lighter than those of the infantry. Light infantry are the eyes of a general, and the givers of sleep and safety to an army. Wherever there is found light cavalry, there should be light infantry. They should be accustomed to the pace of four miles an hour, as their usual marching pace, and to be able to march five miles an hour upon all particular occasions. Most of the powers on the continent have light infantry. It is only of late years, that light infantry came to be used in the British army; but now every regiment has a company of light infantry attached to it, whose station is on the left of the regiment, the right being occupied by the grenadiers.

INFINITE, is a term applied to quantities which are greater than any assigned quantities; also quantities that are less than any assignable quantity, are said to be infinitely small.

Infinite also is sometimes, though improperly, used in the same sense as indefinite, to denote a line or quantity to which no certain bounds or limits are prescribed.

Infinite quantities are not necessarily equal, but may have any ratio to each other; thus a line which is infinitely extended from a certain point, in only one direction, is but half that which is infinitely extended from the same point in two directions. In the same way we may conceive a rectangular plane to be extended in one, two, three, or four different directions; and thus to form four different infinite planes, being to each other as the numbers 1, 2, 3, and 4.

In the same way, a solid may be conceived to be extended in six different directions; forming infinite solids, which shall have to each other certain and determinate ratios.

In the same way we may conceive an infinite quantity, which is infinitely less than another infinite quantity; thus, if two infinite right lines be drawn parallel to each other at any finite distance in a plane infinitely extended in all directions, the infinite space included between them, will be infinitely less than the infinite plane in which they are drawn, for the breadth or distance between these lines is infinitely less than that of the infinitely extended plane.

INFINITE, that which has neither beginning nor end; in which sense God alone is infinite. *See* GOD.

INFINITE, or *Infinitely Great Line*, in Geometry, denotes only an indefinite or indeterminate line, to which no certain bounds or limits are prescribed.

INFINITESIMAL, or INFINITELY SMALL QUANTITY, is that which is so small, as to be incomparable with any finite quantity whatever, or it is that which is less than any assignable quantity.

In the Method of Infinitesimals, the element by which a quantity increases or decreases, is supposed to be infinitely small, and is generally expressed by two or more terms; some of which are infinitely less than the rest, which being neglected, as of no importance, the remaining terms form what is called the difference of the proposed quantity. The terms that are thus neglected, are infinitely less than the other terms of the element, and are the same which arise in consequence of the acceleration or retardation of the generating motion, during the infinitely small instant of time in which the element was generated; so that the remaining terms express the element that would have been formed in that time, if the generating motion had continued uniform.

These differences are, therefore, in exactly the same ratio to each other, as the generating motions or fluxions; and hence, though infinitesimal parts of the elements are neglected, the conclusions are accurately true, in consequence of what may be termed a compensation of errors.

INFLAMMABILITY, that property of certain bodies by which they kindle or catch fire.

INFLECTION, called also DIFFRACTION and DEFLECTION, in Optics, is a property of light, by reason of which, when it comes within a certain distance of any body, it will be either bent from it or towards it; which is a kind of imperfect reflection or refraction.

Experiments and observations seem to reduce the phenomena of inflection to a single principle, *viz.* of the attraction of light towards bodies; which attraction becomes conspicuous when the rays of light pass within a certain distance of their surfaces. Besides their being bent, the rays of light are likewise separated into colours by the vicinity of bodies, and this produces the singular phenomenon of the coloured fringes that accompany the inflection.

INFLECTION, or *Point of Inflection*, in the Higher Geometry, is a point where a curve begins to bend a contraryway.

INFLECTION, in Grammar, the variation of nouns and verbs, by declension and conjugation.

INFLORESCENCE, in Botany, a term used to denote the mode of flowering; the manner in which flowers are supported on their footstalks.

IN FORMA PAUPERIS. When any man who has a just cause of suit, either in chancery or any of the courts of common law, will come before the lord keeper, master of the rolls, either of the chief justices, or chief baron, and make oath that he is not worth five pounds, his debts paid; either of the said judges will, in his own proper court, admit him to sue *in forma pauperis*, or as a poor man, and he shall have counsel, clerk, or attorney assigned him, to do his business, without paying any fees

INFORMATION, in Law, is nearly the same in the crown office, as what in other courts is called a Declaration. *See* Prosecution. Informations are of two sorts: first, those which are partly at the suit of the king, and partly at that of a subject; and secondly, such as are only in the name of the king. The former are usually brought upon penal statutes, which inflict a penalty upon conviction of the offender, one part to the use of the king, and another to the use of the informer. By the statute 31 Eliz. c. 5. no prosecution upon any penal statute, the suit and benefit whereof are limited in part to the king and in part to the prosecutor, can be brought by any common informer after one year is expired since the commission of the offence; nor on behalf of the crown, after the lapse of two years longer; nor where the forfeiture is originally given only to the king, can such prosecution be had after the expiration of two years from the commission of the offence. The informations that are exhibited in the name of the king alone, are also of two kinds: first, those which are truly and properly his own suits, and filed *ex officio* by his own immediate officer, the attorney-general; secondly, those in which, though the king is the nominal prosecutor, yet it is at the relation of some private, or common informer; and they are filed by the king's coroner and attorney in the court of the King's Bench, usually called the *master of the crown office*, who is for this purpose the standing officer for the public. The objects of the other species of information, filed by the master of the crown office, upon the complaint or relation of a private subject, are any gross and notorious misdemeanors, riots, batteries, libels, and other immoralities of an atrocious kind, not peculiarly tending to disturb the government, (for those are left to the care of the attorney-general;) but which, on account of their magnitude or pernicious example, deserve the most public animadversion. And when an information is filed, either thus, or by the attorney-general *ex officio*, it must be tried by a petty jury of the county where the offence arises: after which, if the defendant be found guilty, he must resort to the court for his punishment.

INFORMES Stellæ, unformed stars, are those which have not been yet reduced into constellations, and are otherwise called *sporades*. In the earlier ages of astronomical science, the most conspicuous only of the assemblages of stars were classed as constellations. From the sporades of the ancient, the moderns have arranged many new asterisms, for an account of which we must refer the reader to *Jamieson's Celestial Atlas*.

INFUSION, in Chemistry, is the maceration of any substance in water, or any other liquid, hot or cold, in order to extract its soluble parts. The liquid which is thus impregnated is called an infusion.

INFUSORIA, in Natural History, the fifth order of the class vermes, in the Linnæan system. They are simple microscopic animalcules. The process by which their numbers are sometimes increased, is no less astonishing than their first production. Several of the genera often seem to divide spontaneously into two or more parts, which become new and distinct animals.

INGOT, in the arts, is a small bar of metal made of a certain form and size. The term is chiefly applied to the small bars of gold and silver, intended either for coining, or exportation to foreign countries.

INGRAFTING, in Gardening. *See* Grafting.

INGRATITUDE, the opposite of gratitude. *See* Gratitude. Ingratitude is a crime so shameful, that there was never a man found who would own himself guilty of it; and, though too frequently practised, it is so abhorred by the general voice, that to an ungrateful person is imputed the guilt, or the capability, of all other crimes. The ungrateful are neither fit to love their Maker, their country, nor their friends. Ingratitude perverts all the measures of religion and society, by making it dangerous to be charitable and good natured. However, it is better to expose ourselves to ingratitude, than to be wanting in charity and benevolence.

INGRESS, in Astronomy, is the entrance of the sun into any of the zodiacal signs, especially into Aries.

INHALER, a machine used for steaming the lungs with the vapour of hot water, for the cure of a cough, cold, inflamed throat, &c.

INHERITANCE, a perpetual right or interest in lands, invested in a person and his heirs. *See* Descent.

INHIBITION, a writ to inhibit or forbid a judge from further proceeding in a cause depending before him. Sometimes prohibition and inhibition are put together, as of the same import; but inhibition is most commonly a writ issuing out of a higher court-christian to a lower; and prohibition, of the king's court to an inferior court.

Inhibition, in Scots Law, a diligence obtained at the suit of a creditor against his debtor, prohibiting from selling or contracting debts upon his estate to the creditor's prejudice.

INJECTION, the forcibly throwing certain liquid medicines into the body, by means of a syringe, tube, or the like.

Injection, in Surgery, the throwing in some liquor or medicines into a vein opened by incision. This practice, and that of transfusion, or the conveying the arterial blood of one man, or other animal, into another, were once greatly practised, but are now laid aside.

Anatomical Injection, the filling the vessels of a human, or other animal body, with some coloured substance, in order to make their figures and ramifications visible.

INITIATED, a term properly used in speaking of the religion of the ancient heathens; where it signifies being admitted to the participation of the sacred mysteries. The word comes from the Latin, *initiatus* of *initiare*, *initiari*; which properly signifies to begin sacrificing, or to receive or admit a person to the beginning of the mysteries, or of ceremonies of less importance. The ancients never discovered the deeper mysteries of their religion, nor even permitted some of their temples to be open, to any but those who had been initiated. *See* Mystery.

INJUNCTION, in Law, a writ generally grounded upon an interlocutory order or decree out of the Court of Chancery or Exchequer, sometimes to give possession to the plaintiff, for want of the defendant's appearance; sometimes to the king's ordinary court; and sometimes to the court-christian, to stop proceedings in a cause, upon suggestion made, that the rigour of the law, if it take place, is against equity and conscience in that case; that the complainant is not able to make his defence in these courts, for want of witnesses, &c. or that they act erroneously, denying him some just advantage. The writ of injunction is directed not only to the party himself, but to all and singular his counsellors, attorneys, and solicitors; and if any attorney, after having been served with an injunction, proceeds afterwards contrary to it, the Court of Chancery will commit the attorney to the fleet for contempt. But if an injunction be granted by the Court of Chancery in a criminal matter, the Court of King's Bench may break it, and protect any that proceed in contempt of it.

INK-MAKING. Inks are fluid compounds, designed to form characters, or figures, on paper, parchment, or such other substance as may be fit to receive them. There are two principal kinds of ink,—writing, and printing ink.

To make writing ink. To an infusion of gall-nuts add some solution of sulphate of iron (green copperas) and a very dark-blue precipitate will take place.

This precipitate is the gallic acid of the galls united to the iron of the green vitriol, forming gallat of iron. This is the basis of writing ink; add a little gum-arabic: or take eight ounces of Aleppo galls, in coarse powder; four ounces of logwood in thin chips; four ounces of sulphate of iron (green copperas); three ounces of gum-arabic, in powder; one ounce of sulphate of copper (blue vitriol); and one ounce of sugarcandy. Boil the galls and logwood together in twelve pounds of water for one hour, or till half the liquid has been evaporated. Strain the decoction through a hair sieve or linen cloth, and then add the other ingredients. Stir the mixture till the whole is dissolved, more especially the gum; after which, leave it to subside for twenty-four hours. Then decant the ink, and preserve it in bottles of glass or stone-ware well corked.—Or the following formula for the preparation of good writing ink may be used: for writing ink, the following proportions of materials are deemed best; three ounces of finely bruised galls; one ounce of green vitriol; one ounce of logwood shavings; one once of gum-arabic; half an ounce of bruised cloves; one pint of distilled vinegar; one pint of distilled water. These materials are to be put together in a bottle, and set in a warm place fourteen days, being well shaken every day. The coarser parts being allowed to subside, the ink is poured off; and its quality is materially improved by dissolving a stick of Indian ink and ten grains of corrosive sublimate in each quart; an ounce of brown sugar may also be added, if the ink is intended to be used in the copying press.

To make red writing ink: Take a quarter of a pound of the raspings of Brazil wood, and infuse it two or three days in vinegar. Boil the infusion for an hour over a gentle fire, and filter it while hot. Put it again over the fire, and dissolve in it, first, half an ounce of gum-arabic, and then of alum and white sugar each half an ounce.

Printing Ink. Printers' ink is composed of lamp black and linseed or suet oil boiled, so as to acquire consistence and tenacity. The obtaining of good lamp black appears to be the chief difficulty in making this ink. The ink used by copperplate printers, differs from the last only in that the oil is not so much boiled, and the using of Frankfort black.

Sympathetic inks are such as do not appear after they are written with, but may be made apparent by certain means to be used for this purpose. A variety of substances have been used for this purpose. We shall describe the chief of them.

1. Dissolve sugar of lead in water, write with the solution, and when dry, no writing will be visible. When you want to make it appear, wet the paper with a solution of alkaline sulphuret, and the letters will immediately appear of a brown colour. Even the vapours of these solutions will render the writing apparent.

2. Write with a solution of gold in *aqua regia*, let the paper dry gently in the shade, and nothing will appear; but draw over it a sponge wetted with a solution of tin in *aqua regia*, and the writing will appear of a purple colour.

3. Write with an infusion of galls, and when you wish the writing to appear, dip it into a solution of green vitriol; the letters will appear black.

4. Write with diluted sulphuric acid, and nothing will be visible. To render it apparent, hold it to the fire, and the letters will instantly become black.

5. The juice of lemons, or of onions, a solution of sal ammoniac, green vitriol, &c. answers the same purpose.

6. Green sympathetic ink is made by dissolving cobalt in nitro-muriatic acid: write with the solution, and the letters will be invisible till held to the fire, when they will appear green, but disappear completely again when removed into the cold. In this manner they may be made to appear and disappear at pleasure.

A very pleasant experiment of this kind, is to make a drawing, representing a winter scene, in which the trees appear void of leaves, then put the leaves on with this sympathetic ink; and upon holding the drawing near to the fire, the leaves will begin to appear in all the verdure of spring, and surprise those who are not in the secret.

Blue sympathetic ink is made by dissolving cobalt in nitric acid; precipitate the cobalt by potash; dissolve this precipitated oxyd of cobalt in acetic acid, and add to the solution one-eighth of common salt. This will form a sympathetic ink, which, when cold, will be invisible, but will appear blue by the heat of the fire.

INK, *China*, or *Indian*. This ink is brought over in small oblong cakes, which readily become diffused in water by rubbing, and the blackness remains suspended in it for a considerable time. Dr. Lewis, on examining this substance, found that it consisted of a black sediment insoluble in water, which appeared to be of the nature of the finest lamp-black, and of another substance soluble in water, and which putrified, and when evaporated left a tenacious jelly-like glue or isinglass. It appears probable therefore, that it may be imitated by using a very fine jelly, like isinglass, or size, and the finest lamp black, and incorporating them thoroughly.

Ink, *removing Stains of*. The stains of ink on cloth, paper, or wood, may be removed by almost all acids; but those acids are to be preferred which are least likely to injure the texture of the stained substance. The muriatic acid diluted with five or six times its weight of water, may be applied to the spot, and, after a minute or two, may be washed off, repeating the application as often as may be found necessary. But the vegetable acids are attended with less risk, and are equally effectual. A solution of the oxalic, citric, (acid of lemons,) or tartareous acids, in water, may be applied to the most delicate fabrics, without any danger of injuring them; and the same solutions will discharge writing but not printing ink. Hence they may be employed in cleaning books which have been defaced by writing on the margin, without impairing the text. Lemon-juice, and the juice of sorrel, will also remove ink stains, but not so easily as the concrete acid of lemons, or citric acid.

INNATE Ideas, those supposed to be stamped on the mind from the first moment of its existence, and which it constantly brings into the world with it; it is a doctrine which Mr. Locke has abundantly refuted.

INNS and Innkeepers. If one who keeps a common inn refuse either to receive a traveller as a guest in his house, or to find him victuals or lodging, upon his tendering a reasonable price for them, he is not only liable to render the damages for the injury in an action on the case, at the suit of the party grieved, but also may be indicted and fined at the suit of the king. In return for such responsibility, the law allows him to retain the horse of his guest until paid for his keep; but he cannot retain such horse for the bill of the owner, although he may retain his goods for such bill; neither can he detain one horse for the food of another. An innkeeper, however, is not bound to receive the horse, unless the master lodge there also. Neither is a landlord bound to furnish provisions, unless paid beforehand. If an innkeeper make out unreasonable bills, he may be indicted for extortion; and if either he or any of his servants knowingly sell bad wine, or bad provisions, they will be responsible in an action of deceit. Keeping an inn is not trading, to make a man a bankrupt; but where an innkeeper is a chapman also, and buys and sells, he may on that account be a bankrupt. Innkeepers are clearly chargeable for the goods of guests stolen or lost out of their inns, and this without any contract or agreement for that purpose. But if a person come to an innkeeper, and desire to be entertained by him, which the innkeeper refuses, because in fact his house is already full, whereupon the party says he will shift among the rest of his guests, and there he is robbed, the host shall not be charged.

If a man come to a common inn to harbour, and desire that his horse may be put to grass, and the host put him to grass accordingly, and the horse is stolen, the host shall not be charged.—Innkeepers may detain the person of the guest who eats, till payment. By the custom of London and Exeter, if a man commit a horse to an hostler, and he eat out the price of his head, the hostler may sell him upon the reasonable appraisment of four of his neighbours; yet he cannot justify the taking him to himself at the price it was appraised at.

INNUENDO, is a word used in declarations and law pleadings, to ascertain a person or thing which was not named before; as to say he (innuendo the plaintiff) did so and so, when there was mention before of another person. Innuendo may serve for an explanation, where there is precedent matter, but never for a new charge; it may supply what is already expressed, but cannot add or enlarge the importance of it.

INOCULATION, or Budding, in Gardening, is commonly practised upon all sorts of stone fruits; as nectarines, peaches, apricots, plums, cherries, as also upon oranges and jasmines; and indeed this is preferable to any sort of grafting for most sorts of fruit. For the method of performing it see Gardening.

INOCULATION, in a physical sense, is used for the transplantation of distempers from one subject to another, particularly for the engraftment of the small-pox; which, though of ancient use in the eastern countries, is but a modern practice among us, at least under the direction of art.

In the year 1717, Lady Mary Wortley Montague, wife of the English ambassador at Constantinople, had her son inoculated there at the age of six years; he had but few pustules, and soon recovered. In April 1721, inoculation was successfully tried on seven condemned criminals in London, by permission of his majesty. In 1722, Lady Mary Montague had a daughter of six years old inoculated in this island; soon after which, the children of the royal family, that had not had the small-pox, were inoculated with success; then followed some of the nobility, and the practice soon prevailed. And here we date the commencement of inoculation under the direction of art. From the example of the royal family in England, the practice was adopted in Germany, particularly in Hanover and its adjacent countries.

After Mr. Maitland had succeeded with those he had inoculated in and about London, he introduced the practice into Scotland in the year 1726. Sweden soon followed the example of the British. Russia engaged one of our principal promoters and improvers of this art. And now there are not many countries that do not more or less practise it.

Different Modes of Inoculation.—The practice of inoculation having obtained in every part of the world, it may be grateful, at least to curiosity, to have a general account of the different modes that are and have been adopted in that practice.

Inoculation with the blood of variolous patients has been tried without effect; the variolous matter only produces the variolous disease. The application of the variolous matter takes place in a sensible part only; the activity of the virus is such, that the smallest atom, though imperceptible to any of our senses, conveys the disease as well as the largest quantity. Hence the most obvious method is, the prick of a needle or the point of a lancet dipped in the matter of a variolous pustule. Cotton or thread is used, that is previously rubbed with powdered variolous scabs; this thread is drawn with a needle through the cutis, but not left in. This is the method in some parts of the East Indies. The Indians pass the thread on the outside of the hand, between any of the fingers, or between the fore finger and thumb. The Thessalian women inoculate in the forehead and chin. Some abrade the scarf skins, and rub in the powdered dry scabs, which fall from the pustules of patients with the small-pox.

Many of the Greek women make an oblique puncture with a needle, on the middle of the top of the forehead, on each cheek, the chin, each metacarpus, and each metatarsus; then drop in each a little of the pus just taken warm from a patient, and brought in a servant's bosom. Others in Greece, make several little wounds with a needle in one, two, or more places, in the skin, till some drops of blood ensue; then the operator pours a drop of warm pus fresh from a pustule, and mixes it with the blood as it issues out; then the wound is covered by some with a bandage, by others with half a walnut shell, placed with its concave side over each orifice. The Chinese convey a pellet of variolated cotton, with the addition of a little musk, into the nostrils of the patient; they collect dry pustules, and keep them in a porcelain bottle well corked; and when they inoculate, they mix a grain of musk with three or four grains of the dry scales, and roll them in cotton. This method may be called inodoration.

About Bengal, in the East Indies, the person who intends to be inoculated, having found a house where there is a good sort of small-pox, goes to the bed of the sick person, if he is old enough; or if a child, to one of his relations, and speaks to him as follows:—"I am come to buy the small-pox." The answer is, "Buy if you please." A sum of money is accordingly given, and one, three, or five, pustules, for the number must always be odd, and not exceeding five, extracted whole, and full of matter. These are immediately rubbed on the skin of the outside of the hand between the fore finger and the thumb; and this suffices to produce the disease. The same custom prevails in Algiers, Tunis, Tripoli, and other countries.

Very similar to the custom among the people about Bengal, &c. is that in Arabia, where on some fleshy part they make several punctures with a needle imbued in variolous matter, taken from a pustule of a favourable kind. Here they buy the small-pox, too, as follows:—The child to be inoculated carries a few raisins, dates, sugarplums, or such like, and shewing them to the child from whom the matter is to be taken, asks how many pocks he will give in exchange? The bargain being made, they proceed to the operation; but this buying, though still continued, is not thought necessary to the success of the operation. The Arabs say, that any fleshy part is proper, but generally they insert the matter between the fore finger and thumb on the outside of the arm. The Georgians insert the matter on the fore arm. The Armenians introduce the matter on the two thighs. In Wales, the practice may be termed infriction of the small-pox. There, some of the dry pustules are procured by purchase, and are rubbed hard upon the naked arm or leg.

The practice in some places is, to prick the skin between some of the fingers by means of two small needles joined to one another; and after having rubbed a little of the matter on the spot, a circle is made by means of several punctures of the bigness of a common pustule, and matter is again rubbed over it. The operation is finished by dressing the wound with lint. Another custom is, to mix a little of the variolous matter with sugar, and give it to be drank in any agreeable liquor.

Incisions have been made in the arms and legs, and thread, cotton, or lint, previously dipped in the variolous matter, was lodged in them. The practice of some is, to bathe the feet in warm water, and then secure lint dipped in variolous matter on the instep, or other part of the foot, where the skin is thin. Others apply a small blistering plaster; and when the scarf skin is elevated and slipped off, the variolus matter is applied to the surface of the true skin, and confined there by a little lint or plaster. Scratching the skin with a pin or needle, and then rubbing the part with lint previously dipped in variolous matter, is the custom in some places.—In the Highlands of Scotland they rub some part of the skin with fresh matter, or dip worsted in variolous matter, and tie it about the children's wrists. They observe, that if fresh matter is applied a few days successively, the infection is more certain than by one application.

We have thus given the history of inoculation for the small-pox, which not many years ago was justly regarded as one of the greatest discoveries which had been made for the benefit of mankind, and would still be regarded as such, had it not given place to one still more valuable and important, the vaccine inoculation or cow-pox, which now promises to banish the small-pox from the world. For an account of this, *see* VACCINATION.

It would be quite unnecessary to enter into the detail of the advantages to be derived from inoculation for the small-pox, and the methods of performing or preparing for it formerly practised. But as a curious part of the history of this practice, we shall just barely mention some of the objections which have been urged against it. It has been said, that inoculation for the small-pox is unlawful; that it is bringing a distemper on ourselves, and thus usurping the sacred prerogative of God; that the decrees of God have fixed the commission of every disease, and our precautions cannot prevent what he hath determined; that we should not do evil that good may come; that the patient may die, and then his last moments are distressed, and the future reflections of his friends are grievous; that fear is a dangerous passion in the small-pox, but inoculation increases the causes of fear, by lessening our faith and trust in God; that inoculation does not exempt from future infection; that other diseases are communicated with the matter of the small-pox by inoculating it; that perhaps the disease may never attack in the natural way; that it requires much thought to know what we should do with regard to inoculation; that it endangers others, and that the practice of inoculation comes from the devil.

INORDINATE PROPORTION, is where there are three magnitudes in one rank, and three others proportional to them in another, and you compare them in a different order. Thus suppose the numbers in one rank to be 2, 3, 9, and those of the other rank 8, 24, 36, which are compared in different order, *viz.* 2 : 3 : : 24 : 36; and 3 : 9 : : 8 : 24. Then rejecting the mean terms of each rank, you conclude 2 : 9 : : 8 : 36.

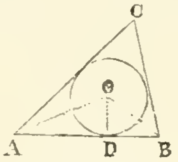
INQUEST, in Law, an inquisition by jurors or a jury.

INQUISITION, in Law, a manner of proceeding by search or examination on the king's behalf, in cases of outlawry, or self-murder, to discover the lands, goods, &c. forfeited to the crown. Inquisition is also had upon extents of lands, tenements, &c., writs of elegit, and where, judgment being had by default, damages and costs are recovered.

INQUISITION, in the Church of Rome, a tribunal in several Roman Catholic countries, erected by the popes for the examination and punishment of heretics.

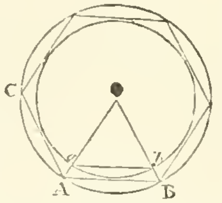
INROLLMENT, in Law, is the registering, recording, or entering in the rolls of the Chancery, King's Bench, Common Pleas, or Exchequer, or by the clerk of the peace, in the records of the quarter sessions, or any lawful act; a statute or recognizance acknowledged, a deed of bargain and sale of lands, and the like. By statute 27 Henry VIII. c. 16, no lands shall pass whereby any estate of inheritance or freehold shall take effect, or any use thereof be made, by reason only of any bargain and sale thereof, except the bargain and sale be made by writing indented, sealed, and within six months inrolled in one of the king's courts of record at Westminster; or else within the county where the lands lie, before the clerk of the peace, and one or more justices. But by 5th Elizabeth, c. 26, in the counties palatine, they may be inrolled at the respective courts there, or at the assizes. Every deed before it is inrolled is to be acknowledged to be the deed of the party before a master of chancery, or a judge of the court wherein it is inrolled, which is the officer's warrant for inrolling it; and the inrolment of a deed, if it be acknowledged by the granter, will be a good proof of the deed itself upon a trial.

INSCRIBED Figure, in Geometry, is one which has all its angles in the sides or periphery of another figure, in which the former is said to be inscribed.



To inscribe a circle in a triangle A B C.

Bisect any two of the angles A and B, and from the point of intersection O, let fall the perpendicular O D; so will O D be the radius and O the centre of the circle required.



To inscribe a Polygon within, or to circumscribe a Polygon about a given Circle.

Bisect two of the angles of the given polygon A and B by the right lines A O, B O; and from the point O, where they meet, with the radius A O, describe a circle which will circumscribe the polygon.

Next, to circumscribe a polygon, divide 360 by the number of sides required, to find the angle A O B; which set off from the centre O, and draw the line A B, on which construct the polygon as in the following problem. 2, On a given line to describe any given regular polygon. Find the angle of the polygon in the table, and at A set off an angle equal thereto; then drawing C A = A B, through the points C A B, describe a circle, and in this applying the given right line, as often as you can, the polygon will be described.

Inscribed *Hyperbola*, that which lies wholly within the angles of its symptotes; as does the common or conical hyperbola.

INSCRIPTION, a title or writing affixed to any thing, to give some farther knowledge of it, or to transmit some important truth to posterity. Antiquaries are very curious in examining ancient inscriptions found on stones and other monuments of antiquity. Sanchoniathon, contemporary, as it is said, with Gideon, drew most of the memoirs whereof his history is composed from inscriptions which he found in temples and on columns, both among the Heathens and the Hebrews.

INSECTS, are not furnished with red blood, but instead of it their vessels contain a transparent lymph. They are destitute of internal bones; but in place of them are furnished with a hard external covering, to which the muscles are attached, which serves them both for skin and bones; they are likewise without a spine formed of vertebræ. They are furnished with articulated legs, six or more. A very great number of insects undergo a metamorphosis, which takes place in all winged insects. They frequently change their skin in the progress of their growth. A very great number of insects are furnished with jaws placed transversely. The wings with which a very great number of insects are furnished, distinguish them from all other animals which are not furnished with a spine composed of vertebræ. Insects are generally oviparous. Scorpions and aphides during the summer months are viviparous. Incubation is not necessary for hatching their eggs. In many insects, such as the crab, lobster, &c. the external covering is very hard, and destitute of organization; it is composed of a calcareous earth, mixed with a small quantity of gelatine, formed by an exudation from the surface of the body. As its hardness would check the growth of the animal, nature has provided a remedy; all of these crustaceous insects cast their shell annually. The skin of most other insects is softer and organized, being formed of a number of thin membranes, adhering closely to one another, putting on the appearance of horn. It owes its greater softness to a large portion of gelatine. The muscles of insects consist of fibres formed of fasciculi; there are commonly but two muscles to produce motion in any of their limbs, the one an extensor, the other a flexor. These muscles are commonly attached to a tendon, composed of a horny substance connected to the part which they are destined to put in motion. In most insects the brain is situated a little above the œsophagus; it divides into two large branches which surround the œsophagus, and unite again under it, from which junction a whitish nervous cord proceeds, corresponding to the spinal marrow of the superior animals, which extends the whole length of the body, forming in its course twelve or thirteen knots or ganglions, from each of which small nerves proceed to different parts of the body. It appears pretty evident that they possess vision, hearing, smell, and touch; as to the sense of taste, we are left to conjecture, for we are acquainted with no facts by which we can prove that insects do not enjoy the sense of taste. The eyes of insects are of two kinds: the one compound, composed of lenses, large, and only two in number; the other are small, smooth, and vary in number from two to eight. The small lenses which form the compound eyes are very numerous; they amount in some insects to many hundreds. The far greater number of insects have only two eyes, but some have three, some four, some six, some eight. The eyes of insects are commonly immovable. Their ears have been discovered at the root of their antennæ, and can be distinctly seen in some of the large kinds, as the lobster. The faculty of smelling is the most perfect of all their senses. Beetles, of various sorts, the different species of dermestes, flies, &c. perceive at a considerable distance the smell of ordure and dead bodies. Insects feed on a great variety of substances; there are few things either in the vegetable or animal kingdoms which are not consumed by some of them. As many insects cannot transport themselves easily in quest of food, to places at a distance from one another, nature has furnished the perfect insects of many species with an instinct which leads them to deposit their eggs in situations where the larvæ as soon as hatched may find that kind of food which is best adapted to their nature. Some insects, at different periods of their existence, make use of aliment of very different properties; the larvæ of some are carnivorous, while the perfect insect feeds on the nectareous juice of flowers. Some authors have asserted that insects have no lungs; but later experience and observation shew, that no species wants them, or at least something similar to them; and in many insects they are larger in proportion to their bodies than in other animals. In most of them they lie at or near to the surface of the body, and send out lateral pores or tracheæ. Insects do not breathe through the mouth or nostrils; there are a number of vessels for the reception of air, placed along on each side of the body, which are commonly called spiracula, which are subdivided into a number of smaller vessels, or bronchiæ; the vessels, or tracheæ, which proceed from the pores on the sides, are not composed of a simple membrane, but are tubes formed of circular rugæ; the spiracula are distinguishable, and are covered with a small scaly plate, with an opening in the middle like a button-hole, which is furnished with membranes or threads, to prevent the admission of extraneous bodies.

Insects are the only animals without vertebræ, in which the sexes are distinguished. All insects are either male or female, except in a few of the genera of the order of hymenoptera. The male is always smaller than the female. The colours of the male are commonly much more brilliant than those of the female, in some insects the colours of the male is totally different from that of the female: the antennæ of the male are commonly of a different form, and larger than those of the female; frequently the males are furnished with wings, while the females have none; the female bee is furnished with a sting, while the male is destitute of one; the males of some insects are furnished with sharp prominent points, resembling horns situated either on the head or breast, which are either not perceptible, or very faintly marked, in the female. The parts essential to generation afford the best distinguishing mark; in most insects they are situated near the extremity of the rectum. *See* Entomology and Larva.

INSOLATION, in Pharmacy, a method of preparing certain fruits, drugs, &c. by exposing them to the heat of the sun's rays; either to dry, to maturate, or to sharpen them; as is done in vinegar, figs, &c. The word comes from the Latin verb *insolare*, which is used by Pliny and Columella, and signifies, to expose to the sun.

INSOLUBILITY, in Chemistry. The insolubility of a substance in a fluid, which is the medium of chemical action, has an influence on that action, somewhat similar to that of cohesion, and is nothing but a modification of it in relation to the fluid in which it is exerted.

INSOLVENT, a term applied to such persons as have not wherewithal to pay their just debts. A person dying, and not leaving estate sufficient to discharge these, is said to die insolvent.

INSPIRATION, among divines, &c. implies the conveying of certain extraordinary and supernatural notices of motions into the mind: or it denotes any supernatural influence of God upon the mind of a rational creature, whereby he is formed to any degree of intellectual improvement, to which he could not or would not, in fact, have attained in his present circumstances in a natural way. Thus the prophets are said to have spoken by divine inspiration.

Some authors reduce the inspiration of the sacred writers to a particular care of Providence, which prevented any thing they had said from failing or coming to nought; maintaining that they never were really inspired either with knowledge or expression. According to others, inspiration is no more than a direction of the Holy Spirit, which never permitted the sacred writers to be mistaken. It is a common opinion, that the inspiration of the Holy Spirit regards only the matter, not the style or words.

INSTALMENT, the establishing a person in some dignity. It is chiefly used for the induction of a dean, prebendary, &c. It is also used for the ceremony whereby the knights of the garter are placed in their rank, in the chapel of St. George, Windsor. It is sometimes termed *installation*.

INSTANT, such a part of duration wherein we perceive no succession; or it is that which takes up the time only of one idea in our minds.

INSTELLON, is used by some authors to denote those parts of space which are beyond the rigions of the solar system.

INSTINCT, an appellation given to the sagacity and natural inclinations of brutes, which supplies the place of reason in mankind.

INSTITUTES, in Literary History, a book containing the elements of the Roman law. The institutes are divided into four books, and contain an abridgment of the whole body of the civil law, being designed for the use of students. *See* Law.

Institute, in Scots Law, when by disposition or deed of entail a number of persons are called to the succession of an estate one after another, the person first named is called the *institute*, the others *substitutes*.

INSTITUTION, in general, signifies the establishing or founding something. In the common law, it signifies the investing a clerk with the spiritualities of a rectory, &c. which is done by the bishop, who uses the following formula: "I institute you rector of such a church with cure of souls; receive your cure and mine."

INSULATED, in Electricity, a term applied to bodies that are supported by electrics, or non-conductors, so that their communication with the earth by conducting substances is interrupted.

INSURANCE, Laws of. By the stat. 14 Geo. III. c. 48. no insurance shall be made on lives, or on any other event wherein the party insured hath no interest; and in all policies the name of such interested party shall be inserted, and nothing more shall be recovered thereon than the amount of the interest of the insured. This, however, does not extend to marine insurances. But as it was a common practice of insuring large sums without having property on board, and which were called wager policies or insurances, interest or no interest, and of insuring the same goods several times over, it was enacted that all insurances, interest or no interest, or without further proof of the interest than the policy, or by way of gaming, or without benefit of salvage to the insurer, should be void except on privateers, or on ships or goods from the Spanish or Portuguese dominions; and that no re-assurance shall be legal, unless the former insurer be insolvent or dead; and that in the East India trade, the lending of money on bottomry, or *ad respondentia*, shall alone have a right to be insured for the money lent; and the borrower shall recover no more upon any insurance than the surplus of his bottomry or *respondentia* bond. No insurance can be made on an illegal voyage. It is generally stipulated in policies, that the insurer shall not be answerable for any partial loss on certain articles, but on others less difficult to be preserved at sea, but liable to partial injuries, shall be liable for any partial loss above five per cent.; and as to all other goods, and the ship and freight, he shall only be liable for such losses above three per cent. But he is liable on all losses, however small, called general average, or losses occasioned by the ship stranding; but this loss must be an immediate, not a remote consequence of the stranding. The commencement of the risk on the ship varies in most cases, and usually continues till the ship has been 24 hours at safe anchor. Upon goods it commences when they are on board, and continues till they are removed or landed. The ship insured must be fit to bear the sea and perform the voyage; and if she deviates from the usual course, and stops at places not usually stopped at, without a proper cause, the contract is void.

Insurance *upon Life*. *See* Assurance.

INTACTÆ, the same as Asymptote.

INTAGLIOS, precious stones, on which are engraved the heads of great men, inscriptions, and the like; such as we frequently see set in rings, seals, &c.

INTEGER, in Arithmetic, a whole number, in contradistinction to a fraction.

INTEGRAL, or Integrant, in Philosophy, appellations given to parts or bodies, which are of a similar nature with the whole.

Integral *Calculus*. *See* Calculus.

Integral *Calculus*, is the reverse of the differential calculus, and corresponds with our inverse method of fluxions; the finding of an integral to a given differential being the same as finding the fluent of a given fluxion, and is performed by the same rules.

INTEGUMENTS, in Physiology, the common coverings which invest the body, as the skin with the fat and cellular membrane. It is also the term of the body.

INTENDMENT, in Law, is the intention, design, or true meaning, of a person or thing, which frequently supplies what is not fully expressed; but though the intent of parties in deeds and contracts is much regarded by the law, yet it cannot take place against the rules of law.

Intendment *of Crimes*. This, in case of treason, where the intention is proved by circumstances, is punishable in the same manner as if it was put in execution. So, if a person enters a house in the night-time, with an intent to commit burglary, it is felony; also, an assault, with an intent to commit a robbery on the highway, is made felony, and punished with transportation, 7 Geo. II. c. 21.

INTENSITY, in Physics, is the degree or rate of power or energy of any quality, as of heat and cold. The intensity of qualities, as gravity, light, heat, &c. vary in the reciprocal ratio of the squares of the distances from the centre of the radiating quality.

INTENT, in the Civil Law, signifies to begin, or commence, an action or process.

INTENTION, in Medicine, that judgment or method of cure which a physician forms to himself from a due examination of symptoms.

Intention, in Physics, the increase of the power or energy of any quality, as heat, cold, &c. by which it stands opposed to remission, which signifies its decrease or diminution.

Intention, in Metaphysics, denotes an exertion of the intellectual faculties with more than ordinary vigour; when the mind with earnestness fixes its view on any idea, considers it on all sides, and will not be called off by any solicitation.

INTERCALARY DAY, denotes the odd day which is inserted in the kalendar every fourth year. *See* BISSEXTILE.

INTERCALARY, an appellation given to the odd day inserted in leap-year; which was so called from *calo calare*, "to proclaim," it being proclaimed by the priests with a loud voice. But the term may with equal propriety apply to the insertion of any period of time, by astronomers and legislators, to make the entire civil year correspond with the passage of the earth in the zodiac, from solstice to solstice, or from equinox to equinox. Thus, the Roman year once consisted but of ten months; afterwards two more were added; and from that time to the present, intercalations have been adopted in the reformation of the calendar. In remote times, when the *Ram* became the leader of the zodiacal signs, it was called *Jubel;* and the jubilee was proclaimed: at the festival of Jupiter Ammon, a ram was slain and eaten by the people of Thebes, and a male lamb was sacrificed by the Hebrews, on the 10th of the mouth Nisan, to commemorate their deliverance from Egypt at the vernal equinox, or when the sun was in Aries.

INTERCEPTED AXIS. *See* ABSCISA.

INTERCOLUMNIATION, in Architecture, denotes the space between two columns, which is always to be proportioned to the height and bulk of the columns.

INTERCOMMONING, in Law, is when the commons of two manors lie together, and the inhabitants of both have, time out of mind, caused their cattle to feed promiscuously on them.

INTERDICT, an ecclesiastical censure, by which the Church of Rome forbids the performance of divine service in a kingdom, province, town, &c. This censure has been frequently executed in France, Italy, and Germany: and in the year 1170, Pope Alexander III. put all England under an interdict, forbidding the clergy to perform any part of divine service, except baptizing of infants, taking confessions, and giving absolution to dying penitents. But this censure being liable to the ill consequences of promoting libertinism and a neglect of religion, the succeeding popes have very seldom made use of it.

INTEREST, is the allowance made for the loan or forbearance of a sum of money, which is lent for, or becomes due, at a certain time; this allowance being generally estimated at so much per cent. per annum, that is, so much for the use of £100 for a year, and this rate is by law fixed not to exceed £5, or in other words, the greatest rate of interest must not exceed 5 per cent. per annum. Interest is either *simple* or *compound.*

Simple interest, is that which is allowed upon the principal, only for the whole time of the loan, or forbearance. The money lent or forborne is called the principal. The sum paid for the use of it, the interest. The interest of £100 for one year, is called the rate per cent. And the sum of any principal, and its interest, together, the amount.

To find the Interest of any Sum for any Period, and at any given Rate per cent.—Say, as £100 is to the rate per cent.; so is any principal to its interest for a year. And then, as one year is to this interest, so is any given time to the interest for that time. Suppose it were required to find the interest of £519. 13*s*. 4*d*. for 3½ years, at 5 per cent. per annum.

```
First, 100 : 5 : : £519. 13s. 4d.  ‖ Again,  1 : 3½ : : 25  19   8
                               5   ‖         2   2              7
                   ─────────────   ‖         ─   ─        ──────────
           £25 . 98    6    8      ‖         2   7    2|181  17   8
                 20                ‖                  ──────────
                 ──                ‖                  £90  18  10
           s. 19 . 66              ‖                  ──────────
                   12              ‖
                   ──              ‖
           d.  8 . 00              ‖
```

That is, the interest of the proposed sum for 1 year, is £25. 19*s*. 8*d*.; and for 3½ years, it is £90. 18*s*. 10*d*. as required.

Again, to find the interest of £250, for 2½ years at 5 per cent.
As £100 : £5 : : £250 : £12. 10*s*.
As 1 year : £12. 10*s*. : : 2½ : £31. 5*s*.

The following tables will much facilitate the computation of simple interest.

TABLE *of the Interest of £1, for any Number of Days, at different Rates of Interest.*

No of Days.	3 per Cent.	Three & a half per Cent.	4 per Cent.	Four and a half per Cent.	5 per Cent.
1	·00008	·00009	·00010	·00012	·00013
2	·00016	·00019	·00021	·00024	·00027
3	·00024	·00028	·00032	·00036	·00041
4	·00032	·00038	·00043	·00049	·00054
5	·00041	·00047	·0 054	·00061	·00068
6	·00049	·00057	·00065	·00073	·00082
7	·00057	·00067	·00076	·00086	·00095
8	·00065	·00076	·00087	·00098	·00109
9	·00073	·00086	·00098	·00110	·00123
10	·00082	·00095	·00109	·00123	·00136
20	·00164	·00191	·00219	·00246	·00273
30	·00246	·00287	·00328	·00369	·00410
40	·00328	·00383	·00438	·00493	·00547
50	·00410	·00479	·00547	·00616	·00684
60	·00493	·00575	·00657	·00739	·00821
70	·90575	·00671	·00767	·00863	·00958
80	·00657	·00767	·00876	·00986	·01095
90	·00739	·00863	·00986	·01109	·01232
100	·00821	·00958	·01095	·91232	·01369
200	·01643	·01917	·02191	·02465	·02739
300	·02465	·02876	·03287	·03698	·04109

This table, it is obvious, will furnish, by the addition of two or three of its numbers, the interest for any number of days, and the following will in the same way find it for any number of years.

TABLE *of the Interest of £1, for any Number of Years not exceeding 25, at different Rates of Interest.*

No. of Years.	3 per Cent.	Three and a half per Cent.	4 per Cent.	Four and a half per Cent.	5 per Cent.
1	·03000	·03500	·04000	·04500	·05000
2	·06000	·07000	·08000	·00000	·10000
3	·09000	·10500	·12000	·13500	·15000
4	·12000	·14000	·16000	·18000	·20000
5	·15000	·17500	·20000	·22500	·25000
6	·18000	·21000	·24000	·27000	·30000
7	·21000	·24500	·28000	·31500	·35000
8	·24000	·28000	·32000	·36000	·40000
9	·27000	·31500	·36000	·40500	·45000
10	·30000	·35000	·40000	·45000	·50000
11	·33000	·38500	·44000	·49500	·55000
12	·36000	·42000	·48000	·54000	·60000
13	·39000	·45500	·52000	·58500	·65000
14	·42000	·49000	·56000	·63000	70000
15	·45000	·52500	·60000	·67500	·75000
16	·48000	·56000	·64000	·72000	·80000
17	·51000	·59500	·68000	76500	·85000
18	·54000	·63000	·72000	·81000	·90000
19	·57000	·66500	·76000	·85500	·95000
20	·60000	·70000	·80000	·90000	1·00000
21	·63000	·73500	·84000	·94500	1·05000
22	·66000	·77000	·88000	·99000	1·10000
23	·69000	·80500	·92000	1·03500	1·15000
24	·72000	·84000	·96000	1·08000	1·20000
25	·75000	·87500	1·00000	1·12500	1·25000

To find the Interest of any Sum, for a given Time, by the preceding Tables.—Add together the interests for the several periods corresponding with the proposed rate per cent. and that sum multiplied by the principal will be the interest required.

Example. Required the interest of £400, for 4 years, 123 days, at 4½ per cent.

Tabular interest for.. 4 years ·1800000
.... 100 days ·0123287
.... 20 days ·0012328
.... 3 days ·0003698

·1939313
400

£.77 | 5725200
20

s. 11 | 45040
12

d. 4 | 92480
4

3 | 69920

Therefore £77. 11*s.* 4¾*d.* is the interest required.

Compound INTEREST, is that which arises from any sum or principal in a given time, by increasing the principal each payment by the amount of that payment, and hence obtaining interest upon both interest and principal. Hence it follows, that, except for the sake of brevity, compound interest would require no other rule than what is given for simple interest, for it is only necessary to find the interest upon the given principal; then add this interest to the principal, and find the interest upon this, and so on, through the whole number of payments. But this would be attended with immense labour, if the time was at all considerable, and therefore other methods of computation become necessary.

Now, in the first place, it is obvious, that if we know the amount of £1 for any period, the amount of any other principal p, will be equal to p times the former; we may therefore limit our investigation to the simple case of finding the compound interest and amount of £1 for any given number of years, at any given rate per cent. Let then r be the amount of £1 for one payment, whether yearly, half yearly, or quarterly. Then, as the amount is always proportional to the principal, we shall have, as $1 : r :: r : r^2 :: r^2 : r^3$, &c.

that is, if the amount of £1, for 1 payment, be r
the amount of £1, for 2 payments $= r^2$
the amount of £1, for 3 payments $= r^3$
the amount of £1, for n payments $= r^n$

and consequently the amount (a) of any principal (p) for (n) payments $= p\,r^n$, which being for the conveniency of calculation put into the logarithmic form, becomes

$$\text{log. of } a = \text{log. } p + n \text{ log. } r.$$

Suppose, for example, the amount of £50, for 15 years, at 5 per cent. were required, the payment being due yearly. Since the interest of £100 is £5, the interest of £1 is ·05, and the amount of £1 in one payment 1·05. Hence by the above formula,

log. 1·05 = 0·021189
mult. by 15

0·317835
log. 50 = 1·698970

2·016805

The natural number to this logarithm is 103·946, or £103. 18*s.* 10*d.* the amount; from which, if the principal be extracted, it will leave the compound interest itself. By this means the amount and compound interest of any sum, for any period and ate per cent. may be readily computed.[*]

But the same may be done still more expeditiously by means of the following table, which exhibits the amount of £1, for any number of years not exceeding 25. Hence the following rule:—

TABLE *Shewing the Amount of £1, in a given Number of Years, not exceeding 25, at any Rate of Compound Interest, from 3 to 6 per Cent.*

Years	3 per Cent.	3 and a half per Cent.	4 per Cent.	4 and a half per Cent.	5 per Cent.	6 per Ct.
1	1·0300	1·0350	1·0400	1·0450	1·0500	1·0600
2	1·0609	1·0712	1·0816	1·0920	1·1025	1·1236
3	1·0927	1·1087	1·1248	1·1411	1·1576	1·1910
4	1·1255	1·1475	1·1698	1·1925	1·2155	1·2624
5	1·1592	1·1876	1·2166	1·2461	1·2762	1·3382
6	1·1940	1·2292	1·2653	1·3022	1·3400	1·4185
7	1·2298	1·2722	1·3159	1·3608	1·4071	1·5036
8	1·2667	1·3168	1·3685	1·4221	1·4771	1·5938
9	1·3047	1·3628	1·4233	1·4860	1·5513	1·6894
10	1·3439	1·4105	1·4802	1·5529	1·6288	1·7908
11	1·3842	1·4599	1·5394	1·6228	1·7103	1·8982
12	1·4257	1·5110	1·6010	1·6958	1·7958	2·0121
13	1·4685	1·5639	1·6650	1·7721	1·8856	2·1329
14	1·5125	1·6186	1·7316	1·8519	1·9799	2·2609
15	1·5579	1·6753	1·8009	1·9352	2·0789	2·3965
16	1·6047	1·7339	1·8729	2·0223	2·1828	2·5403
17	1·6528	1·7946	1 9479	2.1133	2·2920	2·6927
18	1·7024	1·8574	2·0258	2·2084	2·4066	2·8543
19	1·7535	1·9225	2·1068	2·3078	2·5269	5·0255
20	1·8061	1·9897	2·1911	2·4117	2·6532	5·2071
21	1·8602	2·0594	2·2787	2·5202	2·7859	5·3995
22	1·9161	2·1315	2·3699	2·6336	2·9252	5·6035
23	1.9735	2·2061	2·4617	2·7521	3·0715	5·8197
24	2·0327	2 2833	2 5633	2·8760	3·2251	4·0489
25	2·0937	2·3632	2·6658	3·0054	3·3863	4·2918

Find the amount in the table for the given number of years and rate of interest, and multiply this amount by the principal for the amount required. Thus in the preceding example.

Amount by the table = 2·67893
Principal 50

103·94650 = £103. 18*s.* 10*d.*

as before.—This table is only computed for yearly payments, and therefore when the payments are different from these, or when the number of years or payments exceed 25, recourse must be had to the preceding rule.

The accumulation of money, when placed at compound interest, after a certain number of years, goes on exceedingly rapid, and in some instances appears truly astonishing. One penny put out at 5 per cent. compound interest, at the birth of Christ, would, in 1810, have amounted to a sum exceeding in value 357 millions of solid globes of standard gold, each in magnitude as large as this earth! The exact number of globes, according to this computation, is 357,474,600.—*Barlow.*

INTERIOR ANGLE OF A POLYGON, that which is formed internally by the meeting of any of the sides of the figure.

INTERJECTION, in Grammar, an indeclinable part of speech, signifying some passion or emotion of the mind.

INTERLOCUTORY DECREE, in English Law. In a suit of equity, if any matter of fact be strongly controverted, the fact is usually directed to be tried at the bar of the court of King's Bench, or at the assizes, upon a feigned issue. If a question of mere law arises in the course of a cause, it is the practice of the court of Chancery to refer it to the opinion of the judges of the Court of King's Bench, upon a case stated for that purpose. In such cases, interlocutory decrees or orders are made.

INTERLOCUTORY *Judgments*, are such as are given in the middle of a cause, upon some plea, proceeding on default, which is not intermediate, and does not finally determine or complete the suit. But the interlocutory judgments most usually spoken of, are those incomplete judgments, whereby the right of the plaintiff is established, but the *quantum* of damages sustained by him is not ascertained, which is the province of a jury. In such a case, a writ of inquiry issues to the sheriff, who summons a jury, inquires of the damages, and returns to the court the inquisition so taken, whereupon the plaintiff's attorney taxes costs, and signs final judgment.

---

[*] It is no uncommon thing to hear folks talk of a sum of money doubling itself in 14 years; yet the same persons seldom know more of the matter than is found in the ordinary but imperfect rule usually found in such books as Walkingham's Tutor's Assistant,—a book, by the way, that has obtained an undeserved share of popularity, if compared with Kieth's or Joice's Arithmetic.

INTERLOCUTORY *Order*, that which decides not the cause, but only settles some intervening matter relating to the cause. As where an order is made in Chancery, for the plaintiff to have an injunction to quit possession till the hearing of the cause; this order, not being final, is called interlocutory.

INTERLUDE, an entertainment exhibited on the theatre between the acts of a play, to amuse the spectators while the actors take breath and shift their dress, or to give time for changing the scenes and decorations. In the ancient tragedy, the chorus sung the interludes, to shew the intervals between the acts. Interludes, among us, usually consist of songs, dances, feats of activity, concerts of music, &c. Aristotle and Horace give it for a rule, that the interludes should consist of songs built on the principal parts of the drama; but since the chorus has been laid aside, dances, buffoons, &c. ordinarily finish the interludes.

INTERMEDIATES, in Chemistry a term made use of when speaking of chemical affinity. Oil, for example, has no affinity to water unless it be previously combined with an alkali; it then becomes soap, and the alkali is said to be the intermedium which causes the union.

INTERNAL, in general, signifies whatever is within a thing. Euclid (lib. I. prop. 32,) proves that the sum of the three angles of every triangle is equal to two right angles; whence he deduces several useful corollaries. He likewise deduces from the same proposition, this theorem, *viz.* that the sum of the angles of every rectilinear figure, is equal to twice as many right angles as the figure hath sides, excepting or subtracting four.

INTERPOLATION, in Analysis, is the method of finding any intermediate term in a series, its place or distance from the first term being given. This is commonly effected by means of the successive differences of the given terms, and is therefore sometimes called the *differential method*, though this latter expression is more commonly employed to denote the method of summing up of series by means of interpolation; saving, in many cases, immense laborious calculations. Thus, for example, in finding the places of some of the planets, whose motion is not very rapid, it will be sufficiently accurate to find their places by calculation for every fourth or fifth day, and then, by means of the methods above described, their places for all the intermediate days may be found by interpolating between the known terms, which method will give a result much nearer the truth than by proportional parts, because this supposes a uniformity both in motion and time, which is not correct.

Again, in computing the moon's place for any particular hour, supposing its place for every day at noon to be given, the method of interpolations may be applied with great success, the result having scarcely any sensible difference from those that arise from actual computation, and we may thus frequently avoid one of the most laborious of astronomical calculations. By this means also the place of a comet, at any particular time, may be ascertained, from observations made on it prior to, and subsequent to, that precise period, as also the times of the equinoxes and solstices, which are determined much more accurately by this means than can be done by proportional parts, for in this we are obliged to suppose that the sun's declination increases and decreases proportionally to the distance of this body from the equinoctial point; which is evidently a false hypothesis. In fact, astronomy has derived more assistance from this theory than any other of the mathematical sciences, although it has been applied to other purposes with very great success.

INTERPOSITION, the situation of a body between two others, so as to hide them, or prevent their action. The eclipse of the sun is occasioned by an interposition of the moon between the sun and us; and that of the moon, by the interposition of the earth between the sun and moon. *See* ECLIPSE.

INTERROGATION, or *Point of Interrogation*, in Grammar, a character of this form (?) serving to denote a question.

INTERROGATORIES, in Law, are particular questions demanded of witnesses brought in to be examined in a cause, especially in a court of Chancery. And these interrogatories must be exhibited by the parties in suit on each side; which are either direct for the party that produces them, or counter or cross interrogatories. They are to be pertinent, and only to the points necessary; and either drawn or perused by counsel, and to be signed by them.

INTERSECTION, in the Mathematics, signifies the cutting of one line or plane by another. Thus, we say, that the mutual intersection of two planes is a right line.

INTERVAL, in Music, the distance between any given sound and another, strictly speaking, is not measured by any common standard either of extension or duration; but either by immediate sensation, or by computing the difference between the numbers of vibrations produced by two or more sonorous bodies, in the act of sounding, during the same given time. As the vibrations are slower and fewer during the same instant, for example, the sound is proportionally lower or graver; on the contrary, as during the same period the vibrations increase in number and velocity, the sounds are proportionally higher or more acute. An interval in music, therefore, is properly the difference between the number of vibrations produced by one sonorous body of a certain magnitude and texture, and of those produced by another of a different magnitude and texture, in the same time. Intervals are divided into consonant and dissonant. A consonant interval, is that whose extremes, or whose highest and lowest sounds, when simultaneously heard, coalesce in the ear, and produce an agreeable sensation, called by Lord Kames a *tertium quid*. A dissonant interval, on the contrary, is that whose extremes, simultaneously heard, far from coalescing in the ear, and producing an agreeable sensation, are each of them plainly distinguished from the other, produce a grating effect upon the sense, and repel each other with an irreconcileable hostility. In proportion as the vibrations of different sonorous bodies, or of the same sonorous body in different modes, more or less frequently coincide during the same given time, the chords are more or less consonant. When these vibrations never coincide at all in the same given time, the discord is consummate, and consequently the interval absolutely dissonant. But for a full account of these, *see* MUSIC.

INTESTATES: there are two kinds of intestates, one that makes no will at all; and another that makes a will, and nominates executors, but they refuse. The ordinary by special acts of parliament is required to grant administration of the effects of the deceased to the widow or next of kin, who shall first pay the debts of the deceased, and then distribute the surplus among the kindred in the proportions directed by 22 and 23 Car. II. c. 10.

INTESTINA, in Natural History, the first of the five orders of the class vermes, in the Linnæan system. They are of a formation the most simple, being naked animals without limbs. Some live within other animals, some in water, and a few in the earth.

INTESTINES, INTESTINÆ, in Anatomy, the entrails or bowels; those hollow, membranous, cylindrical parts, extended from the right orifice of the stomach to the anus, by which the chyle is conveyed to the lacteals, and the excrements are voided. *See* ANATOMY.

INTONATION, in Music, the action of sounding the notes in the scale with the voice, or any other given order of musical tones. Intonation may be either true or false, either too high or too low, either too sharp or too flat; and then this word intonation, attended with an epithet, must be understood concerning the manner of performing the notes. The executing an air, to form the sounds, and preserve the intervals as they are marked with justness and accuracy, is no inconsiderable difficulty, and scarcely practicable, but by the assistance of one common idea, to which, as to their ultimate test, these sounds and intervals must be referred. These common ideas are those of the key, and the mode in which the performer is engaged; and from the word tone, which is sometimes used in a sense almost identical with that of the key, the word intonation may perhaps be derived. It may also be deduced from the word *diatonii*, as in that scale it is most frequently conversary; a scale which appears most convenient and most natural to the voice. We feel more difficulty in our intonation of such intervals as are greater or less than those of the diatonic order; because, in the first case, the glottis and vocal organs are modified by gradations too large or too complex, in the sound.

INTORSION, in Botany, denotes the bending of any of the parts of a plant towards one side. This admits of certain distinctions. 1. Twining stems which bend towards the left, as in hops, &c. but in convolvulus, &c. to the right. 2. Twining tendrils, which bend to the right and back again; of this kind are the tendrils of most of the leguminous plants. 3. Twisted flowers; in the periwinkle, the petals bend to the left; the pointal in the viscous campion is twisted to the left, as the seed-bud is in the screw tree. In oats, the beard which terminates the husk is twisted like a rope. In the violet, basil, &c. the upper lip of the corolla looks to the ground, and the under lip upwards.

INTRADOS, the internal curve of the arch of a bridge.

INTRENCHMENT, in the Military art, any work that fortifies a post against an enemy who attacks. It is generally taken for a ditch or trench with a parapet. Intrenchments are sometimes made of fascines with earth thrown over them, of gabions, hogsheads, or bags filled with earth, to cover the men from the enemy's fire.

INTRIGUE, an assemblage of events or circumstances, occurring in an affair, and perplexing the persons concerned in it. In this sense, it is used to signify the nodus or plot of a play or romance; or that point wherein the principal characters are most embarrassed through the artifice and opposition of certain persons, or the unfortunate falling out of certain accidents and circumstances. In tragedy, comedy, or an epic poem, there are always two designs. The first and principal is that of the hero of the piece: the second contains the designs of all those who oppose him. These opposite causes produce opposite effects, to wit, the efforts of the hero for the execution of his design, and the efforts of those who thwart it. As those causes and designs are the middle, and these form a knot or difficulty which we call the *intrigue*, that makes the greatest part of the poem. It lasts as long as the mind of the reader or hearer is suspended about the event of those opposite efforts: the solution or catastrophe commences when the knot begins to unravel, and the difficulties and doubts begin to clear up. The intrigue of the Iliad is twofold: the first comprehends three days' fighting in Achilles' absence, and consists on the one side in the resistance of Agamemnon and the Greeks, and on the other, in the inexorable temper of Achilles. The death of Patroclus unravels this intrigue, and makes the beginning of a second. Achilles resolves to be revenged, but Hector opposes his design; and this forms the second intrigue, which is the last day's battle. In the Æneid there are also two intrigues: the first is taken up in the voyage and landing of Æneas in Italy; the second is his establishment there: the opposition he met with from Juno in both these undertakings, forms the intrigue. As to the choice of the intrigue, and the manner of unravelling it, it is certain they ought both to spring naturally from the ground and subject of the poem. Bossu gives us three manners of forming the intrigue of a poem: the first is that already mentioned; the second is taken from the fable and design of the poet; in the third, the intrigue is so laid, as that the solution follows from it of course.

INTRINSIC, a term applied to the real and genuine values and properties, &c. of any thing, in opposition to their extrinsic or apparent values.

INTRODUCTION, in general, signifies any thing which tends to make another in some measure known before we have leisure to examine it thoroughly; and hence it is used on a great variety of occasions. Thus we speak of the introduction of one person to another; the introduction to a book, &c.—It is also used to signify the actual motion of any body out of one place into another, when that motion has been occasioned by some other body.

INTUITION, among Logicians, the act whereby the mind perceives the agreement or disagreement of two ideas, immediately by themselves, without the intervention of any other; in which case the mind perceives the truth as the eye does the light, only by being directed towards it.

INTUITIVE Evidence, is that which results from intuition. Dr. Campbell distinguishes different sorts of intuitive evidence; one resulting purely from intellection, or that faculty which others have called intuition; another kind arising from consciousness; and a third from that new-named faculty common sense, which this ingenious writer, as well as several others, contends to be a distinct original source of knowledge, whilst others refer its supposed office to the intuitive power of the understanding.

INVALID, a person wounded, maimed, or disabled for action by age. At Chelsea and Greenwich are magnificent hospitals, or rather colleges, built for the reception and accommodation of *invalids*, or soldiers and seamen worn out in the service. We have also twenty independent companies of invalids, dispersed in several forts and garrisons. At Paris is a college of the same kind, called *les Invalids*, which is accounted one of the finest buildings in that city.

INVECTIVE, in Rhetoric, differs from reproof, as the latter proceeds from a friend, and is intended for the good of the person reproved; whereas invective is the work of an enemy, and entirely designed to vex and give uneasiness to the person against whom it is directed.

INVENTION, is used for the finding of any thing hidden. The Romish church celebrates a feast on the 4th of May, under the title of invention of the holy cross.

Invention, is also used for subtilty of mind, or somewhat peculiar to a man's genius, which leads him to a discovery of things new; in which sense we say, *a man of invention.*

Invention, in Painting, is the choice which the painter makes of the objects that are to enter the composition of his piece. *See* Painting.

Invention, in Rhetoric, signifies the finding out and choosing of certain arguments which the orator is to use for the proving or illustrating his point, moving the passions or conciliating the minds of his hearers. Invention, according to Cicero, is the principal part of oratory; he wrote four books *De Inventione*, whereof we have but two remaining.

Invention, in Law, a catalogue or schedule orderly made, of all the deceased person's goods and chattels at the time of his death, with their value appraised by different persons, which every executor or administrator is obliged to exhibit to the ordinary at such time as he shall appoint.

IN VENTRE SA MERE, is where a woman is with child at the time of her husband's death, which child if he had been born would be the heir to the land of the husband. A devise to an infant *in ventre sa mere*, is good by way of future executory devise. And where a daughter comes into land by descent, the son born after shall put her out, and have the land.

INVERSE, is applied to a manner of working the rule of three, or proportion, which seems to go backward, or contrary to the order of the common or direct rule. *See* Proportion.

Inverse *Proportion*, or *Inverse Ratio*, in Philosophy, is that in which more requires less, or less requires more. Thus in the case of light and heat flowing from a luminous body, the light and heat are less at a greater distance; and greater at a less distance.

INVERSION, or, as it is in Euclid, *invertendo*, or by inversion, is inverting the terms of a proportion by changing the antecedents into consequents, and the consequents into antecedents; thus, if

$a : b :: c : d$ | Then by inversion it will be

$4 : 9 :: 12 : 27$ | $b : a :: d : c$

$9 : 4 :: 27 : 12$

Inversion, in Music, is a changed position either of a subject or of a chord. The inversion of a subject is produced by giving it a higher or lower situation among the several parts of a score. The inversion of a chord is that changed position of its component parts with respect to its fundamental bass, by which, though the harmony remains the same, the intervals are varied.

Inversion, in Grammar, is where the words of a phrase are ranged in a manner not so natural as they might be. It is a considerable beauty either in verse or prose when we have it from an able hand; it gives vigour and variety to a sentence, and keeps the mind in agreeable suspense and expectation of a marvellous turn and conclusion.

INVERTED, in Music, is derived from the Latin preposition *in* and *vertere*, "to turn any thing a contrary way." It signifies a change in the order of the notes which form a chord, or in the parts which compose harmony, which happens by substituting in the bass, those sounds which ought to have been in the upper part; an operation not only rendered practicable, but greatly facilitated by the resemblance which one note has to another in different octaves, whence we derive the power of exchanging one octave for another with so much propriety and success, or by substituting in the extremes those which ought to have occupied the middle station, and *vice versa*. *See* MUSIC.

INVESTIGATION, properly denotes the searching or finding any thing out by the tracks or prints of the feet; whence mathematicians, schoolmen, and grammarians, came to use the term in their respective researches.

INVESTING A PLACE, is when a general, having an intention to besiege it, detaches a body of horse to possess all the avenues, blocking up the garrison, and preventing relief from getting into the place, till the army and artillery are got up to form the siege.

INVESTITURE, in Law, a giving livery of seisin or possession. There was anciently a great variety of ceremonies used upon investitures, as at first they were made by a certain form of words, and afterwards by such things as had the greatest resemblance to the thing to be transferred; thus, where lands were intended to pass, a turf was delivered by the granter to the grantee. In the church, it was customary for priests to make investiture of ecclesiastical benefices, by delivering to the person they had chosen a pastoral staff and a ring.

INVISIBLE COMBUSTION. This phenomenon was observed by Sir Humphrey Davy. When oxygen and hydrogen gases were made to unite together and inflame, water was the result of their combustion; but Sir H. observed that when these gases were made to pass through tubes of iron which were heated below redness, although no visible combustion appeared to the eye, nevertheless the two gases united, and water was the result. The same effect resulted from the application of a low heat in a variety of ways. In applying this principle to the improvement of the safety lamp, Sir H. Davy suspended some coils of fine platinum wire above the wick of the safety lamp in the wire gauze cylinder. If the lamp should be extinguished by the quantity of fire damp, the glow of the platinum will continue to guide the miner; and by placing the lamp in different parts of the gallery, the relative brightness of the wire shews the state of the atmosphere in those parts. Wherever the wire continues ignited, there is still sufficient oxygen to support respiration; for the ignition ceases when the foul air forms about two-fifths of the volume of the atmosphere. It is an advantage, that the platinum wire is of a very moderate price, and that it is imperishable in its duration. If the foul air be in such quantity as to stop the ignition, whenever the lamp is taken into a purer atmosphere, it again commences; and if the air become sufficiently pure, it will ignite so as again to light the wick of the lamp, which the fire damp had extinguished.

INVOICE, an account, in writing, of the particulars in merchandise, with their value, custom, charges, &c. transmitted by one merchant to another in a distant country. One copy of every invoice is to be inserted in the invoice book, and another must be despatched to the correspondent. A letter of advice is generally subjoined.

INVOICE *Book*, this book is paged, and contains copies of the invoices of goods sent to sea.

INVOLUTE CURVE, in the Higher Geometry, is that which is traced out by the extremity of a thread, as it is folded or wrapped about another figure or curve. *See* EVOLUTE.

INVOLUTION, in Algebra and Arithmetic, is the raising a given number or quantity to any proposed power. In arithmetical and in simple algebraical quantities, this consists only in multiplying the quantity as many times by itself as is necessary to produce the given power; the number of operations being one less than the index of the power to be produced;

thus, $a \times a = a^2$ .... 2d power,
$a \times a \times a = a^3$ .... 3d power,
$a \times a \times a \times a = a^4$ .... 4th power, &c.
So, also, $2 \times 2 = 4$ .... 2d power of 2,
$2 \times 2 \times 2 = 8$ .... 3d power of 2,
$2 \times 2 \times 2 \times 2 = 16$ .... 4th power of 2, &c.

And in the same way we may proceed with compound algebraical quantities; but for binomial ones, it is best to make use of the binomial theorem, the general form of which is as follows, *viz.*

$$(a+b)^n = a^n + n\,a^{n-1}b + \frac{n(n-1)}{1.2}\,a^{n-2}b^2 + \frac{n(n-1)(n-2)}{1.2.3}\,a^{n-3}b^3 +, \&c.$$

Whence
$$\begin{aligned}(a+b)^2 &= a^2 + 2ab + b^2\\ (a+b)^3 &= a^3 + 3a^2b + 3ab^2 + b^3\\ (a+b)^4 &= a^4 + 4a^3b + 6a^2b^2 + 4ab^3 + b\\ \&c. &\quad \&c.\end{aligned}$$

See BINOMIAL.

IODIC ACID, may be obtained in the following way:—Let barytes water act upon iodine, and an insoluble iodate of barytes will result. Wash it and pour upon it sulphuric acid equal to the barytes present, and heat the mixture. The iodic acid will quickly abandon its base, and mix with the water; but a little of the sulphuric acid will also be mixed with it. Add barytes water, and the two acids precipitate together. The density of iodic acid is greater than that of sulphuric acid. Expose it to a heat of from 600 to 700 deg. and it is melted and decomposed into oxygen and iodine. It deliquesces into air, and is very soluble in water. It destroys vegetable colours. It forms combinations with all the fluid and solid acids which it does not decompose.

IODINE, was discovered in Paris, by M. de Courtois, a saltpetre manufacturer, who observed a rapid corrosion of his metal pots in preparing different sorts of sea-weeds which he used in making carbonate of soda. It is from sea-weeds alone that this product of nature is to be obtained. It has not yet been decomposed. Iodine is of a grayish black colour and metallic lustre. It is soft and friable to the touch. Its taste is very acrid. It is a deadly poison. It gives a brown stain to the skin, which soon vanishes by evaporation. The sp. gr. of iodine at $62\frac{1}{2}$ deg. is 4.948. It dissolves in 7000 parts of water, and the solution is of an orange-yellow colour. Iodine is incombustible, but with azote it forms a detonating compound; and in combining with several bodies it produces the phenomenon of combustion. The oxide of sodium, and the subcarbonate of soda, are completely decomposed by iodine.—Iodine forms with sulphur a compound of a grayish black colour, radiated like sulphuret of antimony. Iodine and phosphorus combine with great rapidity at common temperatures, and produce heat without light. Oxygen expels iodine from both sulphur and phosphorus. Hydrogen, whether dry or moist, does not seem to have any action on iodine at the ordinary temperature; but if we expose a mixture of hydrogen and iodine to a red heat in a tube, they unite together, and hydriodic acid is produced, which gives a reddish brown colour to water. Charcoal has no action upon iodine. Several of the metals, as zinc, iron, tin, mercury, attack it readily, even at a low temperature, provided they be in a divided state; they produce but little heat, and but rarely any light. Iron is acted on by iodine in the same way as zinc, and a brown iodine results. Antimony presents, with iodine, the same phenomena as tin; the iodines of lead, copper, bismuth, silver, and mercury, are insoluble in water. This is at least the case with the above mentioned metals. There are two iodines of mercury; the one yellow, the other red; both are fusible and volatile. When iodine and oxides act upon each other in contact with water, its hydrogen unites with iodine to form hydriodic acid; while its oxygen on the other hand produces with iodine, iodic acid. Iodine of mercury has been proposed for a pigment. Iodine has been successfully given internally for the purpose of reducing the goitre, or swelling of the neck.

IONIC ORDER. *See* ARCHITECTURE.

IONIC *Dialect*, in Grammar, a manner of speaking peculiar to the people of Ionia.

IRIDIUM. Mr. Tennant, on examining the black powder left after dissolving platina, which, from its appearance, had been supposed to consist chiefly of plumbago, found it contained two distinct metals, never before noticed, which he has named iridium, and osmium. The former of these was observed soon after by Descostils, and by Vauquelin. Lead unites with it easily, but is separated by cupellation, leaving the iridium on the cupel as a coarse black powder. Copper forms with it a very malleable alloy, which after cupellation, with the addition of lead, leaves a small proportion of the iridium, but much less than in the preceding instance. Silver forms with it a perfectly malleable compound, the surface of which is tarnished merely by cupellation; yet the iridium appears to be diffused through it in fine powder only. Gold remains malleable, and little altered in colour, though alloyed with a considerable proportion, nor is it separable, either by cupellation or quartation.

IRIS, in Anatomy, the interior coloured part of the uvea of the eye, so called because of its variety of colours, iris being the Latin for rainbow. *See* Anatomy and Optics.

IRIS, the name of the rainbow, which see.

Iris *Marina*, the *Sea Rainbow.* This elegant appearance is generally seen after a violent storm, in which the sea water has been much agitated. The celestial rainbow has great advantage over the marine one, in the brightness and variety of the colours, and in their distinctness one from the other; for in the sea rainbow there are scarcely any other colours than a dusky yellow on the part towards the sun, and a pale green on the opposite side; the other colours are not so bright or distinct as to be well determined: but the sea rainbows are more frequent and more numerous than the others. It is not uncommon to see twenty or thirty of them at a time, at noon-day.

IRON, is the most universally diffused metal throughout nature. It is found in animals, in vegetables, and in almost all bodies. It is seldom found native, but combined with a great variety of substances. It is particularly distinguished by its magnetical properties, by its hardness and elasticity, by its ductility, and the property of being welded, but it is very difficult to fuse. Iron soon rusts or oxydates when exposed to the action of water. Iron filings agitated in water become oxydated, and assume the form of a black powder, called *martial Ethiops.* When iron ore is fused in large furnaces, it is made to flow into a kind of mould formed in sand. This first product, which is exceedingly brittle, and not at all malleable, is called cast iron, of which are formed stoves, pipes, cannon, and other articles. Cast, or crude iron, contains carbon and oxygen. The presence of the former appears from its coating the utensils employed in its fusion with plumbago or black lead, which contains nine-tenths of carbon and one of iron.

Crude iron is in three states, white, gray, or black, according as it contains a larger proportion of carbon, an exact proportion of carbon and oxygen, or a larger proportion of oxygen. To render the iron malleable, it must be freed from the carbon and oxygen which it contains; by being fused and kept in that state for some time, stirring and kneading it all the while; by this the carbon and oxygen unite, and are expelled in the form of carbonic acid gas. It is then subjected to the action of large hammers, or to the pressure of rollers, by which the remaining oxyd of iron and other impurities are forced out. The iron is now no longer crystallized or granular in its texture; it is fibrous, and ductile, and is in a purer state, though far from being absolutely pure. It is capable of being welded and worked by hammers into any form. It is now called forged or wrought iron.

There are several varieties of iron in this state, arising from the intermixture of other substances. There is one kind of forged iron, which when cold is ductile, but when heated is extremely brittle; it is also fusible. This is termed hot short iron. Cold short iron possesses precisely the opposite properties, being highly ductile while hot, but when cold extremely brittle. The causes of these peculiarities have not been perfectly explained. Iron is capable of being reduced to a third state, which is that of steel. It is converted into steel by exposing it to heat in contact with carbonaceous substances, which unite themselves with it. Thus we have three states in which iron may exist, *viz.* cast iron, forged iron, and steel.

Cast iron contains too great a quantity of carbonaceous substance; it may be called steel too much steelified; it is therefore exceedingly brittle, and not at all malleable. Forged iron is iron purified from all foreign substances. And in regard to its property of being welded, we may judge from the following account I am about to relate; for were it not for the property which iron has of being welded, that is, united in various parts without the assistance of rivets or solder, this very plentiful metal would be useless for many purposes; but as it is, what may not be accomplished by it! The most stupendous metallic fabric ever executed by man, is the Chinese "bridge of chains," hung over an awful precipice near Ringtung, to connect two mountains. In this bridge there are twenty-one chains, stretched over the valley or abyss; these are bound together by other chains which cross them. The whole forms a perfect and safe road, extending from the summit of one mountain to that of the other. A bridge, upon a similar principle, and of the same material, is now in the act of being erected over the Menai Strait, (to connect Wales with the Isle of Anglesea,) by Mr. Telford, the engineer.

Steel is formed by bedding in charcoal, in a close furnace, alternate layers of malleable iron and charcoal, and exposing them to a strong fire for six or eight days. This process is called *cementation.* During this operation, the iron combines with a quantity of carbon, and is converted into blistered steel. This is either rendered more perfect and malleable, by subjecting it to the operation of the hammer, or it is fused, and cast into small bars, forming cast-steel.

Steel holds a middle rank between cast and forged, or malleable iron. It is composed of very small grains: and when hot, possesses a considerable degree of malleability. It is specifically heavier than forged iron. It is denser than forged iron, but is not harder. To communicate to it the necessary hardness, it must be tempered; that is to say, after being exposed to a greater or less degree of heat, according to the required degree of hardness, it must be suddenly cooled by immersion in cold water. Tempering renders it harder, more elastic, and more brittle. It may be made so hard as to scratch glass. Steel thus hardened, may have its softness and ductility restored, by again beating, and suffering it to cool slowly.

A polished bit of steel, when heated with access of air, acquires very beautiful colours. It first becomes of a pale yellow, then of a deeper yellow, next reddish, then deep blue, and at last bright blue. At this period it becomes red-hot, and the colours disappear; at the same time that the metallic scales, or the black imperfect oxyd of iron which is formed, incrusts its surface. All these different shades of colour indicate the different tempers the steel has acquired by the increase of heat. Artists have availed themselves of this property, to give to surgical and other sharp instruments those degrees of temper which their various uses require. Tempered steel is more elastic, and harder, than iron. Its use is too well known to require elucidation.

Wootz, a metal brought from the East Indies, was examined by Dr. Pearson, who discovered that it was iron united to carbon, and also to oxygen.

The sulphate of iron is common copperas in an impure state.

IRRATIONAL, an appellation given to surd numbers and quantities. *See* Algebra.

IRREGULAR, in Grammar, such inflections of words as vary from the general rules.

IRRITABILITY, in Physiology, is the property peculiar to the muscles, by which they contract upon the application of certain stimuli, without consciousness of action. The laws of irritability are, 1. After every action in an irritable part, a state of rest, or cessation from motion, must take place before the irritable part be again incited to action. 2. Each irritable part has a certain portion or quantity of the principle of irritability which is natural to it, part of which it loses during action, or from the application of stimuli. 3. It regains this lost quantity during its repose or state of rest. 4. Each irritable part has stimuli which are peculiar to it; and which are intended to support its natural action: thus blood, which is the stimulus proper to the heart and arteries, if by any accident it gets into the stomach, produces sickness or vomiting. 5. Each irritable part differs from the rest in regard to the quantity of irritability which it possesses. 6. All stimuli produce action in proportion to their irritating powers. 7. The action of every stimulus is an inverse ratio to the frequency of its application. 8. The more the irritability of a part is accumulated, the more that part is disposed to be acted upon. 9. If the stimuli which keep up the action of any irritable body be withdrawn for too great a length of time, that process on which the formation of the principle depends is gradually diminished, and at last entirely destroyed.

ISATIS Tinctoria, the plant called woad, used in dyeing.

ISINGLASS. This substance is almost wholly gelatine; 100 grains of good dry isinglass containing rather more than 98 of matter soluble in water. Isinglass is made from certain fish found in the Danube, and the rivers of Muscovy. Willoughby and others inform us that it is made of the sound of the Beluga; and Neumann, that it is made of the Huso Germanorum, and other fish, which he has frequently seen sold in the public markets of Vienna. Mr. Jackson remarks, that the sounds of cod, properly prepared, afford this substance; and that the lakes of America abound with fish from which the very finest sort may be obtained. Isinglass receives its different shapes in the following manner. The parts of which it is composed, particularly the sounds, are taken from the fish while sweet and fresh, slit open, washed from their slimy sordes, divested of a very thin membrane which envelopes the sound, and then exposed to stiffen a little in the air. In this state, they are formed into rolls about the thickness of a finger, and in length according to the intended size of the staple; a thin membrane is generally selected for the centre of the roll, round which the rest are folded alternately, and about half an inch of each extremity of the roll is turned inwards. Isinglass is best made in the summer, as frost gives it a disagreeable colour, deprives it of its weight, and impairs its gelatinous principles. Isinglass boiled in milk forms a mild nutritious jelly, and is thus sometimes employed medicinally. This, when flavoured by the art of the cook, is the blancmange of our tables. A solution of isinglass in water, with a very small proportion of some balsam, spread on black silk, is the court plaster of the shops.

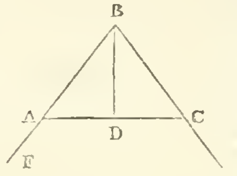
ISIS, Coral, in Natural History, a genus of the vermes zoophyta class and order. *See* Corallines.

ISLAND, or Isle, is a quantity of land entirely surrounded with water. Some conclude that islands are as ancient as the world, and it is by no means probable that the large islands far interior from the continent are new, and that they either arose out of the sea, or were torn from the main land. Nor is it less certain that there have been new islands formed by the casting up of vast heaps of clay, mud, sand, &c. as that, for instance, of Tsongming in the province of Nanquin in China; or by the violence of the sea, which has torn off large promontories from the continent, as the ancients imagined Sicily, and even Great Britain, to have formed. It is also certain that some have emerged above the waves, as Santorini formerly, and three other isles near it lately; the last in 1707, which rose from the bottom of the sea, after an earthquake that was supposed to have loosened it from its hold. Several naturalists are of opinion that islands were formed at the deluge: others think they have been rent and separated from the continent by violent storms, inundations, and earthquakes. These last have observed that the East Indies, which abound in islands more than any other part of the world, are likewise more annoyed with earthquakes, tempests, lightnings, volcanoes, &c. than any other part. Varenius thinks most of their opinions true in some instances, and believes that there have been islands produced each of these ways. St. Helena, Ascension, and other steep rocky islands, he supposes to have become so, by the seas overflowing their neighbouring champaigns. By the heaping up huge quantities of sand and other terrestrial matters, he thinks the islands of Zealand, Japan, &c. were formed. Sumatra and Ceylon, and most of the East Indian islands, he rather thinks were rent off from the main land; and concludes, that the islands of the Archipelago were formed in the same way; imagining it probable that Deucalion's flood might have contributed towards it. The ancients had a notion that Delos and some other islands rose from the bottom of the sea, which, how fabulous soever it might appear, agrees very well with some later observations. Seneca takes notice that the island Thuasia rose out of the Ægean sea in his time, of which the mariners were eyewitnesses. Seneca mentions several floating islands in Italy; and later writers have described not a few of them in other places; but how true soever the histories of these might have been at the time they were written, there remain very few proofs of their truth at present, these islands having either disappeared again, or been fixed to the sides, in some places, so as to have made a part of the sho

Island of Ice, a name given to a great quantity of ice collected into one solid mass, and floating upon the seas, near, or within the polar circles. Many of these fluctuating islands are met with on the coasts of Spitsbergen, to the great danger of the shipping employed in the Greenland fishery.

Island or *Iceland Crystal*, a body famous for its property of a double refraction; but improperly called by that name, as it has none of the distinguishing characters of crystal, being of a genus of spars. It is always found in forms of an oblique parallelopiped, with six sides, and of various sizes, from a quarter of an inch to three inches or more in diameter. It is pellucid, and not much less bright than the purest crystal, and its planes are all tolerably smooth. All the surfaces are placed in the same manner, and it will split off into thin plates, either horizontally or perpendicularly. *See* Optics and Refraction. It is very soft, and easily scratched with the point of a pin: it will not give fire on being struck against steel; ferments, and is perfectly dissolved in aquafortis. It is found in Iceland, from whence it has its name, and in France, Germany, and many other places.

ISOSCELES Triangle, (a word of Greek derivation,) is a triangle of two equal legs or sides; such is the triangle A B C. The angles at the base of an isosceles triangle are equal, and if the sides be produced, the angles under the base are also equal. If the line B D be drawn perpendicular to the base, it will bisect the base and the vertical angle; or if it be drawn to bisect the base, it will be perpendicular to it. This theory is of very extensive use, not only in pure analysis and geometry, but in various other subjects of mathematical inquiry and computation, and particularly in astronomy.



ISOCHRONAL, Isochrone, Isochronus, is applied to such vibrations of a pendulum as are performed in the same space of time.

Isochronal *Line*, that in which a heavy body is supposed to descend without any acceleration.

ISSUE, in Common Law, has various applications, being sometimes taken for the children begotten between a man and his wife; sometimes for profits growing from amercements or fines; sometimes for profits of lands and tenements; but more frequently for the point of matter depending in suit, whereupon the parties join, and put their cause to the trial of the jury. In all the occasions, issue has but one signification, which is, an effect of a cause preceding: as the children are the effect of the marriage between the parents; the profits growing to the king or lord, from the punishment of any man's offence, are the effect of his transgression; the point referred to the trial of twelve men, is the effect of pleading, or process. *See* Plea and Issue.

ISSUES, in Surgery, are little ulcers made designedly by the surgeon, in various parts of the body, and kept open by the patient, for the preservation or recovery of his health.

ISTHMUS, a narrow neck, or slip of ground, which joins two continents, or joins a peninsula to the terra firma, and separates two seas. *See* Peninsula. The most celebrated isthmuses are those of Panama or Darien, which joins North and South America; that of Suez, which connects Asia and Africa; that of Corinth, or Peloponnesus, in the Morea; that of Crim Tartary, otherwise called Taurica Chersonesus; that of the Peninsula Romania and Erisso, or the isthmus of the Thracian Chersonesus, twelve furlongs broad, being that which Xerxes undertook to cut through. The ancients had several designs of cutting the isthmus of Corinth, which is a rocky hillock, about ten miles over; but they were all in vain, the invention of sluices being not then known. There have been attempts too for cutting the isthmus of Suez, to make a communication between the Red Sea and the Mediterranean, but these also failed; and, in one of them, a king of Egypt is said to have lost 120,000 men.

ITCH, a cutaneous disease, supposed to be caused by an insect, a species of the genus acarus, or spider of the human flesh, which, when viewed by a good microscope, is white, with reddish legs, the four hind ones having a long bristle. It is found in the small pellucid vesicles in the hands and joints.

It appears to be not only the cause of the disorder, but the reason why it is so highly infectious.

IVORY, in Natural History, &c. a hard, solid, and firm substance, of a white colour, and capable of a very good polish. It is the tusk of the elephant; and is hollow from the base to a certain height, the cavity being filled up with a compact medullary substance, seeming to have a great number of glands in it. It is observed that the Ceylon ivory, and that of the island of Acheen, do not become yellow in the wearing, as all other ivory does; for this reason the teeth of these places bear a larger price than those of the coast of Guinea. As an article of domestic use, the shavings of ivory, which may be procured of any ivory turner, when boiled in water, form a strong and excellent jelly, equal in every respect to hartshorn jelly; and, at times, of great service to the sick, particularly as the restorative virtues of ivory jelly are very great, and its flavour agreeable. Should the sending to a turner be inconvenient or impracticable, any piece of ivory that may be at hand will answer the purpose by scraping it with a knife. In the manufacture of ivory and bone ornaments, and articles of domestic use, both these substances are softened by submitting them to the action of aquafortis for twelve hours, and subsequently to the juice of berries, we should say that of white currants, if the colour is to be preserved. This operation softens both ivory and bone to so pliant a degree, that they take any shape you may be disposed to give them in a die. They are again hardened by placing the articles in strong vinegar for four or five hours. When ivory is discoloured, it may be bleached or whitened by immersing it an hour in a solution of alum boiled in fair water. Then rub the ivory with a cloth, to prevent it drying too quickly, which sometimes makes it crack, and thus spoils a curious or valuable article.

J.

J, is the jod consonant, which because of its different pronunciation, has likewise a different form, thus J, j. In English it has the soft sound of *g*, nor is it used but when *g* soft is required before vowels, where *g* is usually hard; thus we say *jacks jet, join*, &c. instead of *gack, get, goin*, &c. which would be contrary to the genius of the English language.

JABAROSA, in Botany, a name taken from the Arabic appellation of the mandrake *Jaborosa*, and given to a particular plant which agrees with it in habit, and almost in genus.

JACK, a sort of flag, or colours, displayed from a staff erected on the outer end of a ship's bowsprit. In the British navy, the jack is a small union flag, but in merchant ships the union is bordered with red.

Jack *in the Box*, a large wooden male screw, turning in a female one, which forms the upper part of a strong wooden box, shaped like the frustum of a pyramid. It is used by means of levers passing through holes in it, as a press in packing, and for other purposes.

Jack, in Mechanics, a well-known instrument of common use for raising great weights, being a powerful combination of teeth and pinions, and the whole enclosed in a strong wooden stock or frame B C, and moved by a winch or handle H P; the outside appearing as in fig. 1. In fig. 2, the wheel or rack work is shewn, being the view of the inside when the stock is removed. Though it is not drawn in the just proportions and dimensions, for the rack A B must be supposed at least four times as long in proportion to the wheel Q, as the figure represents it; and the teeth, which will be then four times more in number, to have about 3 in the inch. Now if the handle H P be 7 inches long, the circumference of this radius will be 44 inches, which is the distance or space the power moves through in one revolution of the handle; but as the pinion of the handle has but four leaves, and the wheel Q suppose 20 teeth, or five times the number, therefore, to make one revolution of the wheel Q, it requires 5 turns of the handle, when it passes through 5 × 44 or 220 inches; but the wheel having a pinion R, of 3 leaves, these raise the rack 3 teeth or 1 inch in the same space. Consequently the handle moving 220 times faster than the weight, raises 220 times its own energy. A man therefore who exerts a force of 50 lb, will by this jack raise 5 tons, or 220 × 50 lb = 11000 lb weight. The improved jack has a pall or clock and ratchet, which prevents the machine from running back, if by any accident the weight should overbalance the power exerted. Jacks are sometimes open behind from the bottom almost up to the wheel Q, to allow the lower claw, which in that case is turned up at B, to draw up the weight. This is then kept from going back by hanging the end of the hook S, fixed to a staple, over the curved part of the handle at B.

Fig. 1.

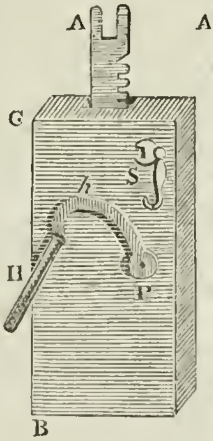
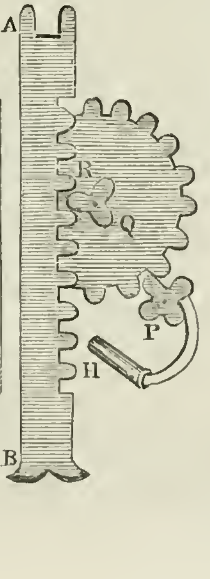
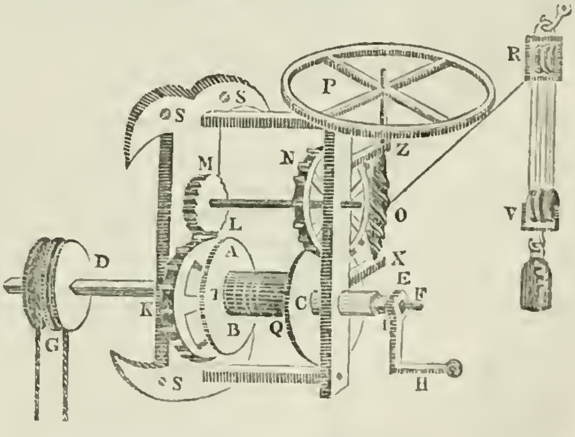


Fig. 2.



Jack is also the name of a well-known engine in the kitchen, used for turning a spit. Here the weight is the power applied, acting by a set of pulleys; the friction of the parts, and the weight with which the spit is charged, are the forces to be overcome; and a steady uniform motion is maintained by means of a fly.

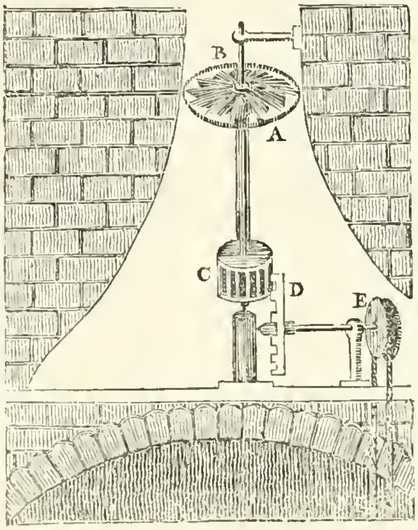
The common worm-jack is represented as follows:—A E C is the barrel round which the cord Q R is wound. K L the main wheel, commonly containing 60 teeth. N the worm wheel of about 30 teeth, cut obliquely. I is the pinion, of about 15. O



the worm or endless screw, consisting of two spiral threads, making an angle of 60 or 70 degress with its axis. X the stud, and Z the loop of the worm spindle. P a heavy wheel, or fly, connected with the spindle of the endless screw, to make the motion uniform. D G the struck wheel fixed to the axis F D. S, S, S, are holes in the frame, by which it may be nailed to a board, and thence to any wall, the end D being permitted to pass through it. H I the handle going upon the axis E T, to wind up the weight when it has run down. R is a box of fixed pulleys, and V a corresponding one of moveable pulleys carrying the weight. The axis E T is fixed in the barrel A C, which axis being hollow, both it and the barrel turn round upon the axis F D, which is fixed to the wheel K L, when it turns in the order B T A; but cannot turn the contrary way, by reason of a catch nailed to the end A B, which lays hold of the cross-bars in the wheel L K.

The weight, by means of a cord Q R, in consequence of its descent, carries about the barrel A B, which by the action of the catch carries the wheel K L, and this moves the pinion L M and wheel N, the latter moving the worm O, and the fly P. Also the wheel L M carries the axis F D with the wheel D G, which carries the cord or chain that goes about the wheel or pulley at the head of the spit. But when the handle H gives motion to the axis in a contrary direction to that given by the weight, the catch is depressed; so that although the barrel B C moves and winds the cord upon it, the wheel D G continues at rest. The time which the jack will continue in motion depends upon the number of pulleys at R and V: and as these increase or decrease, so must the weight which communicates the motion, in order to perform the same work in the same time.

Smoke Jack, is an engine used for the same purpose as the common jack; and is so called from its being moved by means of the smoke or rarefied air, ascending the chimney, and striking against the sails of the horizontal wheel A B, which being inclined to the horizon, is moved about the axis of the wheel together with the pinion C, which carries the wheels D and E; and E carries the chain F, which turns the spit. The wheel A B should be placed in the narrow part of the chimney, where the motion of the smoke is swiftest, and where the largest volume of it must evolve about the sails. Smoke jacks are sometimes moved by spiral flyers, coiling about a vertical wheel, and at other times by a vertical wheel with sails, like the float boards of a mill.



JACTITATION of Marriage, in Law, is when one of the party boasts, or gives out, that he or she is married to the other, whereby a common reputation of their matrimony may ensue. On this ground the party injured may libel the other in the spiritual court; and unless the defendant undertake and make out a proof of the actual marriage, he or she is enjoined perpetual silence on that head.

JALAP, a root which is used in medicine as a purgative. According to Dr. Henry, three kinds of jalap yielded as follows:

	Jalap leger.	Jalap sain.	Jalap pique.
Resin	90	48	72
Extract	75	140	125
Starch	95	102	103
Woody fibre	278	210	200
	538	500	500

JAM, Raspberry, is made by boiling fine ripe raspberries half an hour over a slow fire with their own weight of loaf sugar and half their weight of white currant juice. The liquor should be cleanly skimmed while boiling, and then put into pots, covered with brandy paper.

Strawberry Jam, is made in the same manner.

JAMES'S Powders, or *Antimonial Powders*, a well known preparation, in medicine, of phosphate of lime and antimony. In a recent analysis of this valuable powder, it was found to consist of peroxide of antimony 56·0 parts, phosphate of lime 42·2 parts, oxide of antimony, impurity and loss 1·8 = 1000·0. *See* Antimony. Phosphate of lime is a mineral produced by the combination of lime with phosphoric acid.

In Spain there are entire rocks of phosphate of lime, which the inhabitants hew into building stones for houses, and for the walls of enclosures. This substance is also found in Cornwall, and other parts of England It constitutes the basis of the bones of all animals. The phosphate of lime which is sold in the shops is obtained from these by calcination. This mixed with wood-ashes is used in the manufacture of a kind of flat cups called *cupels*, which are employed by artists for refining gold and silver in; and from it *phosphoric acid* and the luminous substance called *phosphorus* are obtained. Phosphate of lime is said to be a very efficacious medicine in the disease called *rickets*, to which young children are liable.

JANSENISTS, a sect of the Roman Catholics in France, who follow the opinions of Jansenius, bishop of Ypres, nearly like those of Calvin in relation to grace and predestination.

JANUARY, the first month of the year, according to the present mode of reckoning, consisting of thirty-one days.

The Kalendar of Animated Nature for this month, in Middlesex, presents, in its first week, shell-less snails and earth worms. In the second week, the redbreast whistles, the nuthatch chatters, the mistletoe thrush sings, and wagtails appear. Indeed, these pretty wagtails appear on a fine day in all the months of winter. In the third week, the common larks congregate. In the fourth, snails and slugs abound in all the sheltered nooks of our gardens; the hedge sparrow whistles, the large titmouse sings, and some vagrant flies venture on the windows.

The Kalendar of Vegetable Nature around London, presents in the first week of January some plants accidentally in flower, as the laurustinus, continued from December. In the second week, winter aconite, Christmas rose in flower, and hazel catkins, begin to appear; so do also the common honeysuckle buds. In the third week, we see primroses flowering in sheltered places; and the humble daisy and chickweed begin to flower. In the fourth week, mezereon begins to flower, and sometimes spurry, pansy, white scented violet, archangel, and colt's-foot shew their blossoms.

Kitchen Garden. Of *culinary vegetables*, sow early frame and Charlton pease about the beginning, and dwarf marrowfats towards the end of the month. Early mazagan and long-pod beans in the first week and the last; hardy green Egyptian, and brown Dutch lettuces; early dwarf short top radishes.—Protect, by temporary coverings, newly-sown seeds; transplant strong plants; dig and trench vacant ground in dry weather; prepare composts, and destroy insects.

Hardy Fruit Department. Plant fruit trees; protect newly planted trees; prune apples, pears, plums, cherries, gooseberries, currants, and raspberries.—Dig and stir the earth round trees that have been pruned; trench ground for trees; stake newly planted trees; clean trees from moss and mistletoe. Destroy insects by washes. Look over the fruit in your storeroom, and pick out all that are decayed.

Culinary Hot-house Department. Glass-case without heat; sow radishes, lettuce, carrots, small salads, and pease and beans for transplanting.

Hot-beds and Pits. Prepare for making up hot-beds for early cucumbers and melons. Sow early radishes and small salad. Sow carrots on a slight hot-bed, to produce a crop for May. Kidney beans, pease, and potatoes, may also be sown, planted on slight hot-beds.—Give air and water sparingly to pines. Give air and water to forcing houses, and increase the stimuli according to the advancement of your crops.

Flower Garden. Here we have the hot-house and open ground departments. In the latter, plant dried roots of border flowers, transplant daisies as edgings, and protect choice plants by matting, &c. In the hot-house department, attend to alpines, which should have air daily if the weather is not very severe. In hot-beds and pits, force roses, shrubs, and hardy flowers. The mean temperature of the green-house should be 40° maximum, at fire heat 44°. The mean temperature of the dry stove should be 45° with fire heat. Water sparingly, but give air daily.

In the Pleasure Ground and Shrubbery, plant most sorts of deciduous trees in fine weather, and deciduous hedges. Prune deciduous and naturalized shrubs and hedges. Continue to dig in the interior of masses and groups; and dress and gravel. Form and repair lawns and turf verges in mild weather.

Trees in the Nursery Department. Lay out ground, dig and trench, lift, prune, gather, protect trees, and destroy vermin.

Trees in permanent Plantations and Park Scenery. Prepare ground for groves, and screen plantations; plant in dry weather deciduous trees, pines, and larches; prune deciduous trees; cut hedge-rows; enclose and fence ground designed to be planted; fell timber trees, where the bark is no object; and thin crowded plantations.

JAPANNING is the art of varnishing and painting ornaments on wood, as is done by the natives of the island of Japan. All substances that are dry and rigid, or not too flexible; as woods, metals, leather, and paper prepared; admit of being japanned. Wood and metals require no other preparation than to have their surfaces perfectly even and clean; but leather should be securely stretched, either on frames or on boards; as its binding would crack, and force off the varnish. Paper should be treated in the same manner, and have a previous strong coat of size; but it is rarely japanned, till converted into *papier machié*, or wrought into such form, that its flexibility is lost.

Of Japan Grounds. When a priming is used, the work must be smoothed with fish-skin or glass-paper, and being thoroughly clean, is brushed over once or twice with hot size, diluted with two-thirds water, if it is of the common strength. The priming is laid on as evenly as possible. It is a size, of a consistency between the common kind and glue, mixed with as much whiting as will give it a sufficient body of colour to hide the surface it is laid upon. This is repeated till the inequalities are filled up, then the work is cleaned off with Dutch rushes, and polished with a wet rag. When wood or leather is japanned, and no priming used, the best preparation is to lay on two or three coats of coarse varnish, composed in the following manner: Take one pint of rectified spirits of wine, and of coarse seed-lac and resin, each two ounces; dissolve the seed-lac and resin in the spirit, and then strain off the varnish. This varnish, like all others formed of spirit of wine, must be laid on in a warm place; and if it can be conveniently mannaged, the piece of work to be varnished should also be made warm; for the same reason, all dampness should be avoided; as cold or moisture chills this varnish, and prevents its taking hold of the substance on which it is laid. When the work is so prepared, or by the priming with the composition of size and whiting above described, the proper japan ground must be laid on. This is best formed of shell-lac varnish, and the colour desired, except white, which requires a peculiar treatment; and if brightness be wanted, other means must be pursued. The colours used with the shell-lac varnish may be any pigments, which give the tint of the ground desired. As metals never require to be under-coated with whiting, they are treated in the same manner as wood or leather.

White Japan Grounds, are made by the following composition: Take flake-white, or white lead, washed over and ground up with one-sixth of its weight of starch and then dried; temper it properly for spreading with mastich varnish; and lay these on the substance to be japanned, prepared either with or without the under coat of whiting, as ordered above; and then varnish it over with five or six coats of the following varnish.

From a quantity of the best seed-lac, pick out the clearest and whitest grains, reserving the fouler parts for coarse varnishes, or for priming or preparing wood or leather. Of this picked lac take two ounces, and of gum animi three ounces; reduce them to a gross powder, and dissolve them, in about a quart of spirits of wine, and strain off the clear varnish. The seed-lac will give a slight tinge to this composition; but it cannot be avoided, when hard varnish is wanted; though, when a softer will answer the end, the proportion may be diminished, and a little crude turpentine added to the gum animi to take off the brittleness.

A very good varnish, entirely free from brittleness, may be formed by dissolving as much gum animi as the oil will take, in old nut or poppy oil. This must be boiled gently when the gum is put into it. The ground of white colour itself is laid on in this varnish, and then a coat or two of it put over the ground; but when used, it must be well diluted with oil of turpentine. This, though free from brittleness, is liable to suffer by being indented or bruised by any slight strokes; and it will not bear any polish, but may be brought to a smooth surface without, if judiciously managed in the laying it on. It is tedious drying and requires time where several coats are laid on; as the last should be without oil of turpentine.

Blue Japan Grounds are formed of bright Prussian-blue; or of verditer, glazed over by Prussian-blue, or smalt. The colour is best mixed with shell-lac varnish, and brought to a polishing state by five coats of varnish of seed-lac; but the varnish will somewhat injure the colour, by giving a cast of green to a true blue, and fouling a warm blue by the yellow it contains; where a bright blue is required, and a less degree of hardness can be dispensed with, we pursue the method directed in the case of white grounds.

Red Japan Grounds. For a scarlet, vermilion is used; but it has a glaring effect, much less beautiful than the crimson produced by glazing it over with carmine, fine lake, or rose pink. For a bright crimson, instead of glazing with carmine, use Indian lake, dissolved in the spilet of which the varnish is compounded; in this case, instead of glazing with the shell-lac varnish, the polishing coats are only used, as they equally receive and convey the tinge of the Indian lake, which may be dissolved by spirits of wine; but if the highest degree of whiteness is required, use the white varnish.

For Yellow Japan Grounds, employ King's yellow, or turpeth mineral, either alone or mixed with fine Dutch-pink. The effect may be heightened, by dissolving turmeric root in the spirits of wine, of which the upper or polishing coat is made. The spirits of wine must be strained from off the dregs before the seed-lac be added to it, to form the varnish. The seed-lac varnish is not equally injurious here, and with greens; because, tinged with a reddish yellow only, it is little more an addition to the depth of colour. Yellow grounds may be found of Dutch-pink only, which, when good, is not deficient in brightness, though extremely cheap.

Green Japan Grounds, are prepared by mixing King's yellow and Prussian-blue, or turpeth mineral and Prussian-blue; and a cheap but fouler kind, by verdigris, with a little of the above-mentioned yellows, or Dutch-pink. Where a bright green is wanted, the crystal of verdigris, (distilled verdigris,) are employed; to heighten the effect, they are laid on a ground of leaf-gold, when the colour is extremely brilliant and pleasing.

Orange Japan Grounds, are formed by mixing vermilion, or red lead, with King's yellow, or Dutch-pink, or the orange lake, which will make the brightest orange ground that can be produced.

Purple Japan Grounds, are produced by the mixture of lake and Prussian-blue; of a darker hue, by vermilion and Prussian-blue. With respect to the varnish, they are treated as the others.

Black Japan Grounds, (formed without heat,) may be formed by ivory black, or by lamp-black; the former is preferable when good. These are laid on with shell-lac varnish; and have their upper or polishing coats of common seed-lac varnish, the tinge of the varnish being no injury here.

Common Black Japan Grounds on Iron or Copper, (formed by heat.) The work to be japanned is painted over with drying oil and lamp-black; when of a moderate dryness, it must be exposed to such a heat as will change the oil to black, without weakening its tenacity. The stove should not be too hot when the work is put into it, nor the heat increased too fast, else it will blister; the slower the heat is augmented, and the longer it is continued, provided it be restrained within the due degrees, the harder will be the japan. This kind of varnish requires no polish, as that which it receives from the heat when properly managed is sufficient.

Tortoise-shell Japan Ground, produced by heat, is valuable or its great hardness, and its beautiful appearance. Besides, endures to be made hotter than boiling water without damage. It is made by means of a varnish prepared thus:—Take one gallon of good linseed oil, and of umber half a pound; boil them together till the oil becomes brown and thick; strain it through a coarse cloth, and boil it again till it acquire a pitchy consistence, when it will be fit for use.

Having prepared the varnish, clean well the iron or copper plate, or other pieces which are to be japanned, then lay vermilion tempered with shell-lac varnish, or with drying oil diluted with oil of turpentine, very thinly, on the plates intended to imitate the more transparent parts of the tortoise-shell. When the vermilion is dry, brush the whole over with the black varnish, to a true consistence with oil of turpentine; and when it is set and firm, put the work into a stove, where it may undergo a very strong heat, for three weeks or a month, the longer the better.

This ground may be decorated with painting and gilding as other varnished surfaces. This is done after the ground has been hardened by the stove; but it should receive a second annealing with a more gentle heat, after it is finished.

The method of Painting Japan-work. Japan work should be painted with colours in varnish; though for despatch, and in nice work where the freer use of the pencil is required, the colours are tempered in oil. But the oil should previously have a fourth part of its weight of gum animi; or, gum sandarach, or gum mastich dissolved in it. When the oil is thus used, it is diluted with oil of turpentine, for the colours to lie evenly and thin. By this means, fewer of the polishing or upper coats of varnish become necessary.

Water colours are in some instances laid on grounds of gold. These are best, when so used in their proper appearance, without any varnish over them; and they are also sometimes managed to have the effect of embossed work. The colours thus employed for painting, are prepared with isinglass size, corrected by honey or sugar-candy. The body of the embossed work which is raised, is not tinged with the exterior colour, but formed of strong gum water, thickened to a proper consistence by equal parts of bole Armenian and whiting. This gum is laid on the proper figure, and repaired when dry, and the whole may be then painted with the proper colours, tempered with the isinglass size, or shell-lac varnish.

The manner of Varnishing Japan-work. The finishing of japan-work consists in the laying on and polishing the outer coats of varnish, as well in the pieces that have only one simple ground of colour, as those that are painted. This is done with common seed-lac varnish, except where other methods are more expedient. The same reasons which decide as to the fitness of the varnishes, with respect to the colours of the ground, hold equally with regard to those of the painting. Where brightness is the most material point, and a tinge of yellow will injure it, seed-lac gives way to the whiter gums; but where hardness, and a greater tenacity, are essential, the seed-lac must be adhered to; where both are so necessary, that reciprocally one should give way to the other, it is usual to adopt a mixed varnish. This mixed varnish is made of the picked seed-lac. The common seed-lac varnish, the most useful preparation of the kind, may be thus made. Take three ounces of seed-lac, put it into water, to free it from the sticks and filth intermixed with it. To do this, stir it about, and then pour off the water, adding fresh quantities, till it be freed from all impurities. Then dry it, powder it grossly, and put it, with a pint of rectified spirit of wine, into a bottle, of which it will not fill above two-thirds. Shake the mixture, place the bottle in a gentle heat, till the seed-lac is dissolved; repeat the shaking, pour off all that is clear, strain the remainder, and put it in a close bottle.

In using seed-lac white varnish, the substance used in polishing should be itself white; but in other cases, the common sorts of polishing dust may be used. The work to be varnished is placed near a fire, or stove, made perfectly dry: the varnish is then rubbed over with the brushes made for that purpose, beginning in the middle, and passing the brush over to one end, and then with another stroke passing it from the middle to the other end. No part should be twice passed over in forming one coat. When one coat is dry, proceed with a second, and so on six or seven times, till the varnish is sufficiently thick to bear the polish. In common cases, you may polish with a rag dipped in tripoli or rottenstone finely powdered; but before finishing, add a little oil with the powder: when the work is very bright, rub with oil alone, to clean all the powder off. It is an improvement in japan-work to harden the varnish by heat; and where metal forms the body, a hot stove is used.

JARGON, a precious stone found in Ceylon. *See* ZIRCON.

JASPER, in Mineralogy, a species of the clay genus, divided into six sub-species. The Egyptian jasper exhibits two or more colours in concentric zones or bands, more or less regular, with interspersed spots or dendritic figures. It is brittle, and occurs in rolled pieces, which are mostly spherical. Before the blow-pipe it is infusible without addition, and on account of its beautiful colour and great hardness, it is used for similar purposes as the agate. The colours of the *striped jasper* are gray, green, yellow, and red; these are often found together, and arranged in striped and flamed delineations. It occurs in large beds in Saxony, and also in Siberia, where it is of a very beautiful kind. It admits of a high polish, and is used for purposes of ornament chiefly. The *porcelain jasper* generally exhibits but a single colour. Melted before the blow-pipe it is found to consist of silica, 60·75; alumina, 27·25; magnesia, 3·00; oxide of iron, 2·50; potash, 3·66; loss, 2·84. The *common jasper* is found in veins in primitive rocks. It is susceptible of a high polish. *Opal jasper* is found in nests in porphyry, near Tokay in Hungary, in the neighbourhood of Constantinople, and in some Siberian mountains. It is supposed to be the connecting link between jasper and opal, and is distinguishable by the liveliness of its colours, its superior lustre, and constant conchoidal fracture.

JATROPHA, in Botany, a genus of the monœcia monadelphia class and order. Natural order of tricoccæ. Euphorbiæ, Jussieu. There are nine species, of which the most remarkable are: 1. The corcas, or English physic nut. 2. The gossypifolia, cotton-leaved jatropha. 3. The multifida, or French physic nut. 4. The manihot, or bitter cassada, has palmated leaves; the lobes lanceolate, very entire, and polished. 5. The janipha, or sweet cassada, has palmated leaves, with lobes very entire; the intermediate leaves lobed with a sinus on both sides. 6. The elastica, or hevan guianensis, with ternate leaves elliptic, very entire, hoary underneath, and longly petiolated. *See* CAOUTCHOUC. The root of bitter cassada has no fibrous or woody filaments in the heart, and neither boils nor roasts soft. The sweet cassada has all the opposite qualities. The bitter, however, may be deprived of its noxious qualities (which reside in the juice) by heat. Cassada bread, therefore, is made of both, thus: the roots are washed and scraped clean, then grated into a tub: after this, they are put into a hair bag, and strongly pressed, to squeeze out the juice, and the meal is dried in a hot stone bason over the fire. Cassada roots yield a great quantity of starch, which the Brazilians export in little lumps under the name of tapioca.

JAUNDICE, a disease created by a suffusion of bile, and determination thereof to the surface of the body, which is thence tinged yellow.

JAW, LOCKED, a spasmodic contraction of the lower jaw, occasioned generally by some external injury affecting the tendons or ligaments.

JAY, a beautiful bird of the genus Corvus.

JEERS, or JEARS, an assemblage of tackles, by which the lower yards are hoisted up along the mast, or lowered down, as occasion requires; the former of which operations is called *Swaying*, and the latter *Striking*. In a ship of war, the jeers are usually composed of two strong tackles, each of which has two blocks, *viz.* one fastened to the lower mast-head, and the other to the middle of the yard. The two blocks which are lashed to the middle slings of the yard, are retained in this situation by means of two cleats, nailed on each side, whose arms enclose the ropes by which the blocks are fastened to the yard. The two ropes which communicate with these tackles lead down to the deck on the opposite side of the mast, according to the situation of the upper jeer-blocks. In merchant ships the jeers have usually two large single blocks on the opposite side of the mast-head, and another of the same size in the middle of the yard. The rope which communicates with these, passes through one of the blocks hanging on the mast-head, then through the block on the yard, and afterwards through the other hanging block on the mast. To the two lower ends of this rope, on the opposite sides of the mast, are fixed two tackles, each of which is formed of two double blocks, the lower one being hooked to a ring-bolt in the deck, and the upper one spliced or seized into the lower end of the great rope, above which is called the tye. By this contrivance the mechanical power of the tackle below is transmitted to the tye, which communicating with blocks on the yard, readily sways up, or lowers it, either by the effort of both jeers at once on the opposite sides of the mast, or by each of them separately, one after the other. They say a man is brought to the jeers, when going to be punished at the jeer-capstan. This is done in the following manner: a capstan-bar being thrust through the hole of the barrel, the offender's arms are extended at full length cross-wise, and so tied to the bar, having sometimes a basket of bullets, or some other like weight, hanging by his neck. In this posture he continues till he be either brought to confess some plot or crime whereof he is suspected, or that he has suffered what he is sentenced to undergo at the discretion of the captain.

JELLY, a food, medicine, or sweetmeat, prepared from the juice of unripe fruits, boiled to a proper consistency with sugar; or the strong decoctions of the horns, bones, or extremities of animals boiled to such a height as to be stiff and firm when cold, without the addition of any sugar. The jellies of fruits are cooling, saponaceous, and acescent, and therefore are good as medicines in all disorders of the *primæ viæ*, arising from alkalescent juices, especially when not given alone, but diluted with water. On the contrary, the jellies made from animal substances are all alkalescent, and are therefore good in all cases in which an acidity of the humours prevails. The alkalescent quality of these is, however, in a great measure taken off, by adding lemon juice and sugar lemon to them. There were formerly a sort of jellies much in use, called *compound jellies;* these had the restorative medicinal drugs added to them, but they are now scarcely ever heard of.

JELLY *Oat*, a preparation of common oats, recommended by many of the German physicians in all hectic disorders, to be taken with broth of snails or cray fish. It is made by boiling a large quantity of oats, with the husk taken off, with some hartshorn shavings, and currants, together with a leg of veal cut in pieces, and with the bones all broken; these are to be set over the fire with a large quantity of water, till the whole is reduced to a sort of jelly, which, when strained and cold, is firm and hard. A few spoonfuls of this are to be taken every morning, diluted with a bason of either of the abovementioned broths, or any other warm liquor.

JELLY, in Chemistry. If we press out the juice of ripe currants, and many other acid fruits, and let it remain in a state of rest, it partly coagulates into a tremulous soft substance. If we wash the coagulum with a small quantity of water, we obtain jelly approaching to a state of purity, and nearly colourless, unless tinged by the peculiar colouring matter of the fruit; it has a pleasant taste, and a tremulous consistency. It is scarcely soluble in cold, but very soluble in hot water; and when the solution cools, it again coagulates. When long boiled, it loses the property of gelatinizing by cooling.

JESUITS, or the Society of Jesus, in Church History, a cenrated religious order in the Romish Church, founded by Ignatius Loyola, a Spaniard. To the three ordinary monastic vows of chastity, poverty, and obedience, they added a fourth, which was, to go wherever the pope should command. The order was abolished in 1773: but was lately restored by Pope Pius VII. the predecessor of the present pope, and re-established in Italy, Spain, and Switzerland.

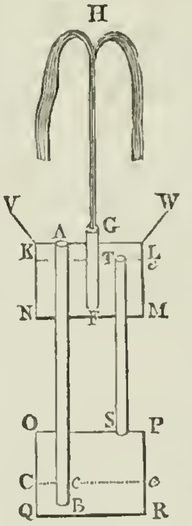
JESUIT'S *Bark*. *See* CINCHONA.

JET, a black inflammable substance of the bituminous kind, harder than *asphaltum*, and susceptible of a good polish. It becomes electrical by rubbing, attracting light bodies like yellow amber. It swims on water, so that its specific gravity must be less than 1000; notwithstanding which it has been frequently confounded with the *lapis obsidianus*, the specific gravity of which, according to Kirwan, is no less than 1744. It also resembles cannel coal extremely in its hardness, receiving a polish, not soiling the fingers, &c.; so that it has also been confounded with this. The distinction, however, is easily made betwixt the two; for cannel coal wants the electrical properties of jet, and is likewise so heavy as to sink in water, its specific gravity being no less than 1273; whereas that of jet, as has already been said, is less than 1000.

Mr. Magellan is of opinion, that the jet is a true amber, differing from the yellow kind only in the mere circumstance of colour, and being lighter on account of the great quantity of bituminous matter which enters into its composition. When burning, it emits a bituminous smell. It is never found in strata or continued masses like fossil stones, but always in separate and unconnected heaps like the true amber. Great quantities of it have been dug in the Pyrenean mountains; also near Batalka, a small town of Portugal, and in Galicia, in Spain. It is found also in Ireland, Sweden, Prussia, Germany, and Italy. It is used in making small boxes, buttons, bracelets, mourning jewels, &c. Sometimes also it is employed, in conjunction with proper oils, in making varnishes; when mixed with lime in powder, it is said to make very hard and durable cement.

JET D'EAU, a French word signifying a fountain that throws up water to some height in the air.

Jets and fountains, though in some situations conducive to pictnresque beauty, are of little utility except in tropical climates. But in the jet or formation of Hiero of Syracuse, the head of water is lower than the orifice, yet as the pressure is communicated by a column of air, this jet d'eau may be considered of great utility in large works where its application is desired.



This figure represents the machine, in which are two vessels, K L M N, and O P Q R, close on all sides. A B is a tube having a funnel at the top, and it passes through the higher vessel without interfering with the fluid therein contained, being fixed or soldered air-tight at its top and bottom. It passes likewise through the top of the lower vessel, being soldered air-tight there also, and it reaches almost to the bottom of this vessel. This tube is open at both ends.

S T is another tube similarly fixed, but in an inverted order, and it is also open at top and bottom. These two tubes support the upper vessel.

A third tube G F, is soldered into the top of the other vessel, and reaches almost to its bottom. This tube is open at both ends, but the orifice G is very small

Fill the upper vessel with water to the height E N, E *e* being its surface a little below T; stop the orifice G with the finger, and pour in water at A; it will pass down B, and compress the air again into less room in O Q R P. Whenever the water in the lower vessel rises to C *c*, the air which formerly occupied the whole of the spaces O P Q R and E *e* L K, will now be contained in the spaces *o* P *c* C and K L *e* E; and its elasticity will be in equilibrio with the weight of the column of water, whose base is the surface E *e*, and whose height is A *c*: hence if your finger be now removed from the orifice G, the fluid will spout up through that tube as high as it is long, or equal to the altitude *c* H; and while there is any water in the vessel K L M N, there will be a discharge through the orifice.

The height of the water measured from the basin V A W to the surface of the water in the lower vessel, is always equal to the height measured from the top of the jet to the surface of the water in the vessel K L M N; and as the surface E *e* is constantly falling, and the water in the under vessel always rising, the height of the jet is perpetually decreasing, until it is shorter by the depth of K L M N, which is empty, added to the depth of O P Q R, which is continually falling; and so soon as the jet has fallen thus low, it ceases to play.

JETSAM, any thing thrown out of a ship being in danger of wreck, and by the waves driven to the shore.

JETTE, the border made round the stelts under a pier, in certain old bridges, being the same with starling, consisting of a strong framing of timber filled with stones, chalk, &c. to preserve the foundations of the piers from injury.

JETTY Head, a name usually given in the royal dock yards to that part of a wharf which projects beyond the rest; but more particularly the front of a wharf, whose side forms one of the cheeks of a dry or wet dock.

JEWEL, any precious stone, or ornament beset with them. *See* Diamond, Ruby, &c.

Jewels made a part of the ornaments with which the Jews, Greeks, and Romans, especially their ladies of distinction, adorned themselves. So prodigious was the extravagance of the Roman ladies in particular, that Pliny the elder says, he saw Lullio Paulina with an equipage of this kind, amounting, according to Dr. Arbuthnot's calculation, to £322,916. 13*s.* 4*d.* of our money. It is worthy of observation, that precious stones among the Romans and all the ancients were much scarcer, and consequently in higher esteem, than they are amongst us, since a commerce has been opened with the Indies. The ancients did not know how to cut and polish them to much perfection; but coloured stones were not scarce, and they cut them very well either hollow or in relief. When luxury had gained ground amongst them, the Romans hung pendants and pearls in their ears; and for this purpose, the ears of both sexes were frequently bored. *See* Ears.

JEWEL-BLOCKS, in Shipping, two small blocks, which are suspended at the extremity of the main and fore top-sail-yards, by means of an eye-bolt driven from without into the middle of the yard-arm parallel to its axis. The use of these blocks is to retain the upper part of the top-mast studding-sails beyond the sheets of the top-sails, so that each of these sails may have its full force of action, which would be diminished by the encroachment of the other over its surface. The halliards, by which those studding-sails are hoisted, are passed through the jewel-block, whence, communicating with a block on the top-mast-head, they lead downwards to the top or decks, where they may be conveniently hoisted.

JEWS, in Church History, the descendants of Judah the son of Jacob, and of the Israelites, commonly denominated the Twelve Tribes of Israel. This name was first given to those Jews who returned from the captivity of Babylon, because the tribe of Judah made the most conspicuous figure among them. The following is a summary of their religous creed: 1. That God is the creator and active supporter of all things. 2. That God is one, and eternally unchangeable. 3. That God is incorporeal, and cannot have any material properties. 4. That God shall eternally subsist. 5. That God is alone to be worshipped. 6. That whatever has been taught by the prophets is true. 7. That Moses is the head and father of all contemporary doctors, and of all those who lived before, or shall live after him. 8. That the law was given by Moses. 9. That the law shall always exist, and never be altered. 10. That God knows all the thoughts and actions of men. 11. That God will reward the observance, and punish the breach, of his law. 12. That the Messiah is to come, though he tarry a long time. 13. That there shall be a resurrection of the dead when God shall think fit. In England, in former times, the Jews and all their goods belonged to the chief lord where they lived. By stat. Edward I. the Jews, to the number of 15,000, were banished out of England; and never returned till Oliver Cromwell re-admitted them. Whenever any Jew shall present himself to take the oath of abjuration in pursuance of the 10 George III. c. 10, the words, upon the true faith of a Christian, shall be omitted. If Jewish parents refuse to allow their Protestant children a maintenance suitable to their fortune, the Lord Chancellor, upon complaint, may make such order therein as he may think proper.

Jews' *Harp*, in Music, an instrument well known among the lower classes in this country, almost the only musical instrument made use of by the inhabitants of the island of St. Kilda.

JIB, the foremost sail of a ship, being a large stay-sail extended from the outer end of the bow-sprit, prolonged by the jib-boom towards the fore-top-mast-head. In cutters and sloops the jib is on the bowsprit, and extends towards the lower mast-head. The jib is a sail of great command with any side wind, but especially when the ship is close-hauled, or has the wind upon her beam; and its effort in casting the ship, or turning her head to leeward, is very powerful and of great utility, particularly when the ship is working through a narrow channel.—*Flying Jib*, a sail sometimes set upon a boom, rigged out beyond the jib-boom.—*Middle Jib*, a similar sail, sometimes set between the two preceding, being extended from the end of the jib-boom, while the inner jib-tack is near half way down or on the boom.

Jib-Boom, is a continuation of the bowsprit forward, being run out from the extremity in a similar manner to a top-mast on a lower-mast, and serving to extend the bottom of the jibs and the stay of the fore-top-gallant-mast. It is usually attached to the bowsprit by means of two large boom-irons, or by one boom-iron and a cap on the outer end of the bowsprit, or by a cap without, and a strong lashing within, instead of a boom-iron, which is generally the method of securing it in small merchant ships: when it can be drawn in upon the bowsprit as occasion requires, which is frequently practised when the ship enters a harbour, where it might very soon be broken or carried away, by the vessels which are moored therein or passing by under sail.—*Flying Jib-Boom*, is a boom extended beyond the preceding by means of two boom-irons, and to the foremost end of which the tack of the flying-jib is hauled out.

JIGGER, a machine consisting of a piece of rope about five feet long, with a block at one end, and a sheave at the other, used to hold on the cable when it is heaved into the ship by the revolution of the windlass. The jigger is particularly useful when the cable is either slippery with mud or ooze, or when it is stiff or unwieldy; in both of which cases it is very difficult to stretch it back from the windlass by hand, which however is done with facility and expedition by means of the jigger, in the following manner: the end of the rope to which the sheave is fastened by a knot, is passed round the cable close to the windlass, and the hind part of the rope coming over the sheave, is stretched aft by means of another rope passing through the jigger-block. As soon as the last rope is extended, the turn of the former about the cable is firmly retained in its position by the compression of its hind part under the sheave, acting upon what may be called the neck of the jigger.

Fleet Jigger, a term used by the man who holds on the jigger, when, by its distance from the windlass, it becomes necessary to fleet or replace it in a proper state of action, for as the cable continues to be heaved into the ship, it is evident that the jigger, which is fastened on a particular part thereof, stretching it back, will be removed further aft, by every turn of the windlass, and the effort of the jigger will be lessened in proportion to its distance from the windlass; accordingly, when the man gives the above notice, another at the windlass immediately fixes his handspike between the deck and the cable, so as to jam the latter to the windlass, and prevent it from running out till the jigger is replaced near the windlass.

Jigger-*Tackle*, a light small tackle consisting of a double and a single block, and used by seamen on sundry occasions.

JOBBER, a person who undertakes jobs, or small pieces of work. In some statutes, *jobber* is used for a person who buys and sells for others, and is equivalent to broker. Hence *jobbing*, the business of a jobber.

Stock Jobbing denotes the practice of trafficking in the public funds, or of buying and selling stock with a view to its rise or fall. The term is commonly applied to the illegal practice of buying and selling stock for time, or of accounting for the differences in the rise or fall of any particular stock for a stipulated time, whether the buyer or seller be possessed of any such real stock or not. *See* Stock, *Broker*.

JOINERY, the art of working in wood, or of fitting various pieces of timber together. It is called by the French small work, to distinguish it from carpentry, which is employed about large works. *See* Architecture, Building, and House.

JOINT, in general, denotes the juncture of two or more things. The joints of the human body are called by anatomists *articulations. See* Anatomy. The suppleness to which the joints may be brought by long practice, from the time of infancy, is very surprising. Every common posture-master shews us a great deal of this; but one of the most wonderful instances we ever had of it, was in a person of the name of Clark, and famous for it in London, where he was commonly known by the name of *Clark the posture-master*. This man had found the way, by long practice, to distort many of the bones, of which nobody before had ever thought it possible to alter the position. He had such an absolute command of his muscles and joints, that he could almost disjoint his whole body. So that he once imposed on the famous Mullens by his distortions in such a manner, that he refused to undertake his cure; but, to the amazement of the physician, no sooner had he given over his patient, than he saw him restore himself to the figure and condition of a proper man, with no distortion about him.

Joint *Actions*, in personal actions, several wrongs may be joined in one writ; but actions founded upon a tort and a contract cannot be joined.

Joint *and Several*, an interest cannot be granted jointly and severally.

Joint *Lives*, lease for years to husband and wife, if they or any issue of their bodies should so long live, has been adjudged so long as either the husband, wife, or any of their issue, should live.

Joint *Stock Companies*, are trading associations with a stock consisting of many shares, in which the individuals gain or lose in proportion to their shares. For very large undertakings, such as the making of a canal or building a bridge, where the capital of a few men is inadequate, the union of many individuals may be necessary and sometimes profitable. In general, joint stock companies are not profitable to the individual shareholders, although they may be beneficial to the persons who are paid for managing the concern on behalf of the body at large. It is a common delusion, that the share-holder is not responsible beyond the amount of his share, but except it be a corporate body, every farthing of his property is liable for all the debts and obligations of the company. To put a stop to delusive schemes, which led many persons to their ruin, the statute of 16 Geo. I. c. 18, was enacted, commonly called the bubble act; it has, however, been evaded, or allowed to remain inoperative. Many joint stock companies obtain an act of parliament, by which they may sue or be sued in the name of their chairman, secretary, or any of their members, which they otherwise could not do, as it would be necessary in all the records and pleadings to recapitulate the names and designations of all the shareholders, which in some cases would be impossible, and in all cases extremely tedious and expensive.

Joint *Tenants*, are those that hold lands or tenements by one title, without partition. The creation of an estate in joint tenancy depends on the wording of the deed or devise by which the tenant claims title, and cannot arise by act of law. If any estate be given to a plurality of persons, without adding any restrictive, exclusive, or explanatory words, this makes them immediately joint tenants in fee of the lands. If there be two joint tenants, and one release the other, this passes a fee without the word heirs. Joint tenants may make partition; the one party may compel the other to make partition, which must be by deed; that is to say, all the parties must by deed actually convey and assure to each other the several estates which they are to take and enjoy severally and separately; joint tenants must jointly implead and be jointly impleaded with others. If one joint tenant refuse to join in an action, he may be summoned and severed; but if the person severed die, the writ abates in real actions, but not in personal and mixed actions.

JOINTURE, in Law, generally signifies a settlement of lands and tenements, made on a woman in consideration of marriage.

JOISTS, or Joysts, in Architecture, those pieces of timber framed into the girders and summers, on which the boards of the floor are laid.

JONK, Jonque, or Junk, a kind of small ship, very common in the East Indies. These vessels are about the size of fly-boats, and differ in the form of their building, according to the different methods of naval architecture used there. The sails are frequently made of mats, and the anchors of wood.

JOURNAL, a sort of diary, or daily register of the ship's course and distance, the winds and weather, together with a general account of whatever is material to be remarked in the period of a sea voyage, such as the shifting, reducing, or enlarging the quantity of sail, the condition of the ship and her crew, the discovery of other ships or fleets, lands, shoals, breakers, soundings, &c.

Journal, a day book, register, or account of what passes daily. *See* Book-Keeping.

JOURNEYMAN, properly one who works by the day only; but the word is now used for any one who works under a master, either by the day, the year, or the piece.

JOY, in Ethics, is that passion which is produced by love, regarding its object as present, either immediately or in prospect, in reality or imagination. The operation of joy sometimes effects the functions of the body, by increasing the secretion of perspiration and some others.

JUBILEE, a time of public and solemn festivity among the ancient Hebrews. This was kept every fiftieth year; and began about the autumnal equinox. At this time all slaves were released, all debts annihilated, and all lands, &c. however alienated, were restored to their first owners. During this whole year all kind of agriculture was forbidden, and the poor had the benefit of the harvest, vintage, and other productions of the earth.—The Christians, in imitation of the Jews, have likewise established jubilees, which began in the time of pope Boniface VIII. in the year 1300, and are now practised every twenty-five years; but these relate only to the pretended forgiveness of sins, and the indulgences granted by the church of Rome.

JUDGMENT, among Logicians, a faculty, or rather act, of the human soul, whereby it compares its ideas, and perceives their agreement or disagreement. *See* Logic and Metaphysics.

Judgment, in Law, is the sentence pronounced by the court upon the matter contained in the record. Judgments are of four sorts. First, where the facts are confessed by the parties, and the law determined by the court; as in case of judgment upon demurrer. Secondly, where the law is admitted by the parties, and the facts disputed; as in the case of judgment or verdict. Thirdly, where both the facts, and the law arising thereon, are admitted by the defendant; which is the case of judgment by confession or default; or, lastly, when the plaintiff is convinced that either fact, or law, or both, are insufficient to support his action, and therefore abandons or withdraws his prosecution; which is the case in judgments upon a *nonsuit* or *traxit*. The judgment, though pronounced or awarded by the judges, is not their determination or sentence, but the determination and sentence of the law. It is the conclusion that naturally and regularly follows from the premises of law and fact, which stands thus: Against him who hath rode over my corn, I may recover damages by law; but A hath rode over my corn, therefore I shall recover damages against A. If the major proposition be denied, this is a demurrer in law; if the minor, it is then an issue of fact; but if both be confessed or determined to be right, the conclusion or judgment of the court cannot but follow; which judgment or conclusion depends not therefore on the arbitrary caprice of the judge, but on the settled and invariable principles of justice. The judgment, in short, is the remedy prescribed by law for the redress of injuries; and the suit or action is the vehicle or means of administering it. What that remedy may be, is indeed the result of deliberation and study to point out; and therefore the style of the judgment is, not that it is decreed or resolved by the court, for then the judgment might appear to be their own; but, "it is considered," *consideratum est curiam*, that the plaintiff do recover his damages, his debt, his possession, and the like; which implies, that the judgment is none of their own; but the act of law, pronounced and declared by the court, after due deliberation and inquiry. See Blackstone's Comment. iii. 396.

Judgment, in criminal cases, is the next stage of prosecution, after *trial* and *conviction* are passed, in such crimes and misdemeanors as are either too high or too low to be included within the benefit of clergy. For when, upon a capital charge, the jury have brought in their verdict 'guilty' in the presence of the prisoner, he is either immediately, or at a convenient time soon after, asked by the court, if he has any thing to offer why judgment should not be awarded against him? And in case the defendant be found guilty of a misdemeanor, (the trial of which may, and does usually, happen in his absence, after he has once appeared,) a *capias* is awarded and issued, to bring him in to receive his judgment; and if he absconds, he may be prosecuted even to outlawry. But whenever he appears in person, upon either a capital or inferior conviction, he may at this period, as well as at his arraignment, offer any exceptions to the indictment, in *arrest* or stay of judgment; as, for want of sufficient certainty in setting forth either the person, the time, the place, or the offence. And if the objections be valid, the whole proceedings shall be set aside: but the party may be indicted again; and even may take notice, 1. That none of the statutes of *jeofails*, for amendment of errors, extend to indictments, or proceedings in criminal cases; and therefore a defective indictment is not cited by a verdict, as defective pleadings in civil cases are. 2. That in favour of life, great strictness has at all times been observed, in every point of an indictment. Sir Matthew Hale indeed complains, "that this strictness is grown to be a blemish and inconvenience in the law and the administration thereof; for that more offenders escape by the ever-easy ear given to exceptions in indictments, than by their own innocence; and many times gross murders, burglaries, robberies, and other heinous and crying offences, remain unpunished by these unseemly niceties, to the reproach of the law, to the shame of the government, to the encouragement of villany, and to the dishonour of God." And yet, notwithstanding this laudable zeal, no man was more tender of life than this truly excellent judge.—A pardon also may be pleaded in arrest of judgment; and it has the same advantage when pleaded here as when pleaded upon arraignment; *viz.* the saving the attainder, and, of course, the corruption of blood: which nothing can restore but parliament, when a pardon is not pleaded till after sentence. And certainly, upon all accounts, when a man hath obtained a pardon, he is in the right to plead it as soon as possible. *See* PARDON.

Praying the benefit of clergy, may also be ranked among the motions in arrest of judgment. *See* BENEFIT of CLERGY.

If all the resources fail, the court must pronounce that judgment which the law hath annexed to the crime. Of these, some are capital, which extend to the life of the offender, and consist generally in being hanged by the neck till dead; though in very atrocious crimes other circumstances of terror, pain, or disgrace, are superadded, as, in treasons of all kinds, being drawn or dragged to the place of execution: in high treason committed by a female, the judgment is, to be burned alive. But the humanity of the English nation has authorized, by a tacit consent, an almost general mitigation of such parts of these judgments as savour of torture or cruelty: a sledge or hurdle being usually allowed to such traitors as are condemned to be drawn; and there being very few instances (and those accidental or by negligence) of any person's being embowelled or burned, till previously deprived of sensation by strangling. Some punishments consist in exile or banishment, by abjuration of the realm, or transportation beyond the seas; others in loss of liberty, by perpetual or temporary imprisonment. Some extend to confiscation by forfeiture of lands or moveables, or both, or of the profits of lands for life; others endure a disability of holding offices or employments, being heirs, executors, and the like. Some, though rarely, occasion a mutilation or dismembering, by cutting off the hand or ears: others fix a lasting stigma on the offender, by slitting the nostrils, or branding in the hand or face. Some are merely pecuniary, by stated or discretionary fines; and, lastly, there are others that consist principally in their ignominy, though most of them are mixed with some degree of corporeal pain, and these are inflicted chiefly for such crimes as either arise from indigence, or render even opulence disgraceful; such as whipping, hard labour in the house of correction, the pillory, the stocks, and the ducking-stool. Disgusting as this catalogue may seem, it will afford pleasure to a British reader, and do honour to the British laws, to compare it with that shocking apparatus of death and torment, to be met with in the criminal codes of almost every other nation in Europe. And it is moreover one of the glories of our laws, that the nature, not always the quantity or degree, of punishment is ascertained for every offence; and that it is not left in the breast of any judge, nor even of a jury, to alter that judgment which the law has beforehand ordained for every subject alike, without respect of persons. For if judgment were to be the private opinions of the judge, men would then be slaves to their magistrates, and would live in society without knowing exactly the conditions and obligations which it lays them under. And, besides, as this prevents oppression on the one hand, so on the other, it stifles all hopes of impunity or mitigation with which an offender might flatter himself, if his punishment depended on the humour and discretion of the court. Whereas, where an established penalty is annexed to crimes, the criminal may read their certain consequence in that law, which ought to be the unvaried rule, as it is the inflexible judge of his actions.

JUGLANS, in Botany, *Walnut Tree*, a genus of the monœcia polyandria class and order. Natural order of amentaceæ. Terebintaceæ, Jussieu. There are eight species, of which J. regia, common walnut, is a very large and lofty tree, with strong spreading boughs. There are several varieties, but they all vary again when raised from the seed, and nuts from the same tree will produce different fruit. The wood is in great request, on account of its fine grain and colour. The husks and leaves being macerated in warm water, and the liquor poured on grass walks and bowling-greens, will infallibly kill the worms, without endangering the grass.

JUGULARES, in Natural History, an order of fishes according to the Linnæan system. They have their ventral fins situated before the pectoral fins, and as it were under the throat. Their body is sometimes covered with scales, and sometimes not. With a very few exceptions, they have spines in the dorsal and anal fins, and their gills have bony rays. Of this order are the following genera; blenius, callyonumus, gadus, kurtels, trachinus, uranoscopus.

JUICE, denotes the sap of vegetables, or the liquors of animals. *See* ANATOMY, BLOOD, PLANTS, SAP, &c. The juices of several plants are expressed, to obtain their essential salts, and for several medicinal purposes, with intention either to be used without further preparation, or to be made into syrups and extracts. The general method of extracting these juices is, by pounding the plant in a marble mortar, and then by putting it into a press. Thus is obtained a muddy and green liquor, which generally requires to be clarified, as we shall soon observe. Juices which are not acid, and not very mucilaginous, are spontaneously clarified by rest and gentle heat.—Fermentation is also an effectual method of clarifying juices which are susceptible of it; for all liquors which have fermented, clarify spontaneously after fermentation. The juices, especially before they are clarified, contain almost all the same principles as the plant itself, because in the operation by which they are extracted, no decomposition happens, but every thing remains, as to its nature, in the same state as in the plant. Most vegetable juices coagulate when they are exposed to the air, whether they are drawn out of the plant by wounds, or naturally run out; though what is called naturally running out, is generally the effect of a wound in the plant, from a sort of canker, or some other internal cause. Different parts of the same plant yield different juices.

Among those juices of vegetables which are clammy and readily coagulate, there are some which readily break with a whey. The great wild lettuce, with the smell of opium, yields the greatest plenty of milky juice of any known British plant. These juices, as well as the generality of others which bleed from plants, are white like milk, but there are some of other colours. The juice of the great celandine is of a fine yellow colour; it flows from the plant of the thickness of cream, and soon dries into a hard cake, without any whey separating from it. Another yellow juice is yielded by the seed-vessels of the yellow centaury in the month of July, when the seeds are full-grown. This is very clammy; it soon hardens altogether into a cake, without any whey separating from it. Another kind of juices, very different from all these, are those of a gummy nature. Some of these remain liquid a long time, and are not to be dried without the assistance of heat; and others very quickly harden of themselves, and are not inflammable. Some plants yield juices which are manifestly of an oily nature. These, when rubbed, are not at all of a clammy nature, but make the fingers glib and slippery, and do not at all harden on being exposed to the air. If the stalk of elecampane be wounded, there flows out an oily juice swimming upon a watery one. The stalks of the hemlock also afford a similar oily liquor swimming upon the other; and in like manner the white mullein, the berries of ivy, the bay, juniper, and the fruit of the olive, when wounded, shew their oil floating on the watery juice. Some of these oily juices, however, harden into a kind of resin.

JULIAN CALENDAR, *Epoch—Period—Year, &c.* *See* the respective articles.

JULY, the seventh month of the year; during which the sun enters the sign Leo. The word is derived from the Latin *Julius*, the surname of Caius Julius Cæsar, the dictator, who was born in it. Marc Antony first gave this month the name July, which before was called Quintilis, as being the fifth month of the year in the old Roman kalendar established by Romulus, which began in the month of March. For the same reason, August was called Sextilis; and September, October, November, and December, still retain the name of the first rank.

On the 10th day of this month the dog-days are commonly supposed to begin; when, according to Hippocrates and Pliny, the sea boils, wine turns sour, dogs go mad, the bile is increased and irritated, and all animals decline and languish.

The Kalendar of Animated Nature round London for this month. The cuckoo loses her voice; the stone curlew whistles occasionally late at night; the golden-crested wren chirps; the quail calls; the cuckoo-spit or frog-hopper abounds; young frogs migrate; the great horse-fly appears; and young partridges fly.

In the *Kalendar of Vegetable Nature*, we see enchanter's nightshade, lavender, pinks, and carnations, in bloom. Raspberries and gooseberries are now ripe, potatoes are in flower, and asparagus in berry, and truffle may now be dug up in commons and forests. But for the various productions of this season, the reader must consult works which give them in detail.

JUMP, in Mining, is one among the numerous appellations, which the dislocations of the strata have received from the practical miners of different districts. The process or convulsion of nature, is frequently called "*The heaving of the lode,*" and exhibits a phenomenon in mining, which the science of mineralogy has not yet been able to solve.

JUMPER. This is a name given to a long iron tool with a steel chisel-like point, much used in mines, for drilling or boring of holes in rocks which are to be blasted with gunpowder. Some have confounded this instrument with another, generally called a *Gad*. The *Gad*, however, is a different tool, having no connexion with the holes bored to be used in the blasting process. In some places, Jumper and Borer are terms of synonymous import, applied promiscuously to the same tool. The term Jumper is also given to a Christian sect well known in Wales, and remarkable for their eccentricity.

JUNCI LAPIDEI, in Natural History, the name given by authors to a species of fossil coral of the tabularia kind, and composed of a congeries of small tubules, which are usually round and striated within.

JUNCTURE, in Oratory, is a part of composition particularly recommended by Quintilian, and denotes such an attention to the nature of the vowels, consonants, and syllables, in the connexion of words, with regard to their sound, as will render their pronunciation most easy and pleasant, and best promote the harmony of the sentence. Thus, the coalition of two vowels occasioning a hollow and obscure sound, and likewise of some consonants rendering it harsh and rough, should be avoided; nor should the same syllable be repeated at the beginning and end of words, because the sound becomes hereby harsh and unpleasant.

JUNCUS, *the Rush*, a genus of plants belonging to the hexandria class; and in the natural method ranking under the fifth order Tripetaloideæ. *See* BOTANY.

JUNE, the sixth month of the year, during which the sun enters the sign Cancer. In this month is the summer solstice. *See* CANCER, the *Crab*, (page 142.) for the astronomical and physical relation of June. The word is from Junius or *à Junone*, for the goddess says in Ovid, *Junius à nostro nomine nomen habet*. There are, however, two other topics that solicit our attention here, and we shall therefore develop them in the sequel of this article.

1. *Kalendar* for this month, in the south of Britain. *In Animated Nature*, during the first week, we see the wasp, and several species of the bee and butterfly tribes, with the hedge-sparrow and fly-catcher. In the second week, the burnet moth and forest fly shew themselves, and bees swarm. In the third week, flies, butterflies, moths, beetles, and other insects appear. In the fourth week, insects abound, singing birds begin to retire to the woods, and lose their song.

2. *The Kalendar of Vegetable Nature* round London. In the first week, water-lilies flower, and numerous other plants. In the second week, the vine, raspberry, and elder are in flower. Scotch roses, broom, and nettle flower; and wheat is now in the ear. In the third week, a great variety of plants flower, also many of the pasture grasses and late wheats. In the fourth week, currants ripen, strawberries abound, young shoots of trees and shrubs attain their length; oats and barley flower, &c.—For particulars which relate to the kitchen garden, to fruit trees, to flowers, to pleasure grounds, and shrubberies, we must refer the reader to treatises written professedly on these subjects.

JUNGERMANNIA, in Botany, a cryptogamia genus of plants, very numerous in species, as well as distinct in character. It was thus named by Ruppius and Micheli, who have been followed by all botanists since their day, in honour of Lewis Jungermann, professor of botany at Altdorf, and afterwards at Giessen, in the early part of the seventeenth century. The plants of this genus have hitherto been but inaccurately defined.

JUNGIA, in Botany, so named by the younger Linnæus, in memory of Joachim Jungius, a learned German botanist, of the seventeenth century.

JUNIPA, in Botany, the name of a tree of the Caribbee Islands, and some other places, to which peculiar properties are ascribed. The fruit is said to yield a juice as clear as water, which communicates a fine purple dye, but being rubbed twice on the same spot, the purple gives place to black. This singular tincture, according to report, cannot be got out by soap or any other method of cleansing, and yet, after about nine or ten days, the colour wholly disappears of its own accord. The same authors who vouch for the above properties, also assert, that hogs and parrots feeding on this fruit, have their flesh and fat all tinged throughout of a violet colour.

JUNIPERUS, in Botany, *Juniper Tree*, a genus of the diœcia monadelphia class and order. Natural order of coniferæ. There are twelve species: some of these are lofty handsome trees; but the common juniper is a low shrub, seldom more than three feet in height. The female flowers are succeeded by roundish berries, at first green, and when ripe of a dark purple colour. They continue on the bush two years, and are sessile in the axil of the leaves. Juniper is common in all the northern parts of Europe. The berries have a strong smell; and a warm pungent sweet taste, followed by a bitterish one.

JUNK, any remnants or pieces of old cable, which are usually cut for the purpose of making POINTS, MATS, GASKETS, SENNIT, &c. which see.

JUNO. Under the article Astronomy, a few observations were made on this planet, to which we now make the following additions. Juno is situated between the orbits of Mars and Jupiter, was discovered by Mr. Harding at the observatory of Lilienthal, near Bremen, on the evening of the first of September, 1804. While this astronomer was forming an atlas of all the stars, as far as the eighth magnitude, which are near the orbits of Ceres and Pallas, he observed, in the constellation Pisces, a small star of the eighth magnitude, which was not mentioned in the "Histoire Celeste" of La Lande; and being ignorant of its longitude and latitude, he put it down in his chart as nearly as he could estimate with his eye. Two days afterwards the star disappeared, but he perceived another which he had not seen before, resembling the first in size and colour, and situated a little to the south-west of its place. He observed it again on the 5th of September, and finding that it had moved a little farther to the south-west, he concluded that this star belonged to the planetary system.

The planet Juno is of a reddish colour, and is free from that nebulosity which surrounds Pallas. Its diameter, and its mean distance, are less than those of the other new planets. It is distinguished from all other planets by the great eccentricity of its orbit; and the effect of this is so extremely sensible, that it passes over that half of its orbit, which is bisected by its perihelion, in half the time that it employs in describing the other half, which is farther from the sun. From the same cause, its greatest distance from the sun is double the least distance, the difference between the two distances being about 127 millions of miles. Though there is no nebulous appearance around the planet Juno, yet it appears, from the observations of Schroeter, that it must have an atmosphere more dense than that of any of the old planets of the system. A very remarkable variation in the brilliancy of this planet has been observed by this astronomer. He attributes it chiefly to changes that are going on in its atmosphere, though he thinks it not improbable that these changes may arise from a diurnal rotation performed in 27 hours. The following elements were calculated by Buckhardt.

Mean longitude, 31st Dec. 1804, noon	$1^{s}\ 12^{\circ}\ 17'\ 23''$
Place of ascending node	$5^{s}\ 21^{\circ}\ 6'\ 0''$
Place of perihelion in 1805....................	$1^{s}\ 29^{\circ}\ 49'\ 23''$
Eccentricity	0·25096 ....
Inclination of orbit..........................	$21^{\circ}\ 0'$......
Ditto.	$13^{\circ}\ 4'$......
Mean distance	2.057 ......
Diameter in English miles, according to Schroeter	1425 ......
Apparent mean diameter, as seen from the earth, according to Schroeter.	$3''$·057......

JUPITER, among Alchemists, signifies the philosopher's gold. The gentlemen of this profession apply every thing to their art which the mythologists mention of the god Jupiter, asserting that the ancient fables are only to be understood in a figurative sense.

Jupiter, and his Satellites. *See* Astronomy.

JURATS, magistrates in the nature of aldermen, for the government of several corporations.

JURIES, in Common Law, consist of twelve or twenty-four men, sworn to inquire into facts, and declare the truth upon such evidence as shall appear before them. Trial by jury is very ancient in this country. It seems to have been coeval with the existence of its civil government; and some authors have endeavoured to trace their establishment up so high as the ancient Britons. It is certain that while the Saxons held dominion among us, juries were well known, and some have ascribed their origin to Woden, their great legislator and captain. Juries are, in these kingdoms, the supreme judges in all courts and in all causes, in which either the life, property, or reputation, of any man is concerned. This is the distinguishing privilege of every Briton, and one of the most glorious advantages of our constitution; for as every one is tried by his peers, the meanest subject is as safe and as free as the greatest. *See* the article Trial.

JURISDICTION, a power or authority which a man has to do justice in cases of complaint made before him. There are two kinds of jurisdiction, the one *ecclesiastical*, the other *secular*.

Secular Jurisdiction, belongs to the king and his justices or delegates. The courts and judges at Westminster have jurisdiction all over England, and are not restrained to any county or place; but all other courts are confined to their particular jurisdictions; the first is *tenere placita*, to hold pleas, and the plaintiff may sue either there or in the king's courts. Another is the cognizance of pleas, where a right is invested in the lord of the franchise to hold pleas; and is the only person that can take advantage of it, by claiming his franchise. The third sort is an exempt jurisdiction, as where the king grants to some city, that the inhabitants shall be sued within their city, and not elsewhere, though there is no jurisdiction that can withstand a *certiorari* to the superior courts.

Ecclesiastical Jurisdiction, belongs to bishops and their deputies. Bishops, &c. have two kinds of jurisdiction; the one internal, which is exercised over the conscience in things purely spiritual; and this they are supposed to hold immediately of God. The other is contentious, which is a privilege some princes have given them of terminating disputes between ecclesiastics and laymen.

JURISPRUDENCE, the science of what is just or unjust; or the knowledge of laws, rights, customs, statutes, &c. necessary for the administration of justice. *See* Law.

JUROR, Jurator, in a legal sense, is one of those twenty-four or twelve men who are sworn to deliver truth upon such evidence as shall be given them touching any matter in question. The punishment of petty jurors attainted of giving a verdict contrary to evidence, willingly, is very severe.

JURY, a certain number of men sworn to inquire into and try a matter of fact, and to declare the truth upon such evidence as shall appear before them.

JURYMAST, a temporary or occasional mast, erected in a ship in the place of one that has been carried away by tempest, battle, &c. Jurymasts are sometimes erected in a new ship, to navigate her down the river, or to a neighbouring port, where her proper masts are prepared for her.

JUSTICE, in a moral sense, is one of the four cardinal virtues, which gives every person his due. Civilians distinguish justice into two kinds, *communicative* and *distributive*. The former establishes fair dealing in the mutual commerce between man and man; and includes sincerity in our discourse, and integrity in our dealings. The effect of sincerity is mutual confidence, so necessary among the members of the same community; and this mutual confidence is sustained and preserved by the integrity of our conduct. Distributive justice is that by which the differences of mankind are decided, according to the rule of equity. The former is the justice of individuals; the latter, of princes and magistrates. Fidelity and truth are the foundation of justice. As to be perfectly just is an attribute of the Divine nature—to be so to the utmost of our ability, is the glory of man.

Justice, is also an appellation given to a person deputed by the king to administer justice to his subjects; whose authority arises from his deputation, and not by right of magistracy. Of these justices there are various kinds in England, *viz.*

Chief Justice of the Court of King's Bench, is the capital justice of Great Britain, and is a lord by his office. His business is chiefly to hear and determine all pleas of the crown; that is, such as concern offences against the crown, dignity, and peace of the king; as treason, felonies, &c. The officer was formerly not only chief justice, but also chief baron for the exchequer, and master of the court afterwards. He usually sat in the king's palace, and there executed that office formerly performed *per comitem palatii;* he determined in that place all the differences happening between the barons and other great men. He had the prerogative of being vice-regent of the kingdom whenever the king went beyond sea, and was usually chosen to that office out of the prime nobility; but his power was reduced by king Richard I. and king Edward I. His office is now divided, and his title changed from *capitalis Angleæ justiciarius*, to *capitalis justiciarius ad placita coram rege tenenda*, or, *capitalis justiciarius banci regii.*

Chief Justice of the Common Pleas, he who with his assistants hears and determines all causes at the common law; that is to say, all civil causes between persons, as well personal as real; and he is also a lord by his office.

Justices of Assize, were such as were wont by special commission to be sent to this or that county to take assize for the case of the subjects. For, whereas these actions pass always by jury, so many men might not without great damage and charge be brought up to London; and therefore justices, for this purpose, by commissions particularly authorized, were sent down to them. These continue to pass the circuit by two and two twice every year through all England, except the four northern counties, where they go only once, despatching their several businesses by several commissions, for they have one commission to take assizes, another to deliver gaols, and another of oyer and terminer. In London and Middlesex a court of general gaol delivery is held eight times in the year. All the justices of peace of any county wherein the assizes are held, are bound by law to attend them, or else are liable to a fine, in order to return recognizances, &c. and to assist the judges in such matters as lie within their knowledge and jurisdiction, and in which some of them have been probably concerned by way of previous examination. *See* Assizes and Jury.

Justices in Eyre, (justiciarii itinerantes or *errantes,)* were those who were anciently sent with commission into divers counties to hear such causes especially as were termed pleas of the crown; and that for the ease of the subject, who must else have been hurried to the courts of Westminster, if the causes were too high for the county courts. According to some, these justices were sent once in seven years; but others suppose that they were sent oftener. Camden says, they were instituted in the reign of king Henry II. A.D. 1184; but they appear to be of an older date. They were somewhat like our justices of assize at this day, though for authority and manner of proceeding very different.

Justices of Gaol Delivery, those commissioned to hear and determine causes appearing to such as for any offence are cast into prison. Justices of gaol delivery are empowered, by the common law, to proceed upon indictments of felony, trespass, &c. and to order execution or reprieve, and they have power to discharge such prisoners as upon their trials shall be acquitted; also all such against whom, on proclamation made, no evidence appears to indict; which justices of oyer and terminer, &c. may not do.

Justice of Nisi Prius, are now the same with justices of assize. It is common adjournment of a cause in the Common Pleas to put it off to such a day. *Nisi Prius justiciarii venerant ad eas partes ad capiendes* assizes: from which clause of adjournment, they are called justices of *nisi prius,* as well as justices of assize, on account of writ, and actions they have to deal in.

Justices of Oyer and Terminer, were justices deputed on some special occasions to hear and determine particular causes. The commission of oyer and terminer is directed to certain persons upon any insurrection, heinous demeanour, or trespass committed, who must first inquire, by means of the grand jury or inquest, before they are empowered to hear and determine by the help of the petit jury. It was formerly held that no judge or other lawyer could act in the commission of oyer and terminer, or that of gaol delivery, within the county where he was born or inhabited; but it was thought proper by 12 Geo. II. cap. 27. to allow any man to be a justice of oyer and terminer, and general gaol delivery, within any county of England.

Justices of the Peace, are persons of interest and credit, appointed by the king's commission to keep the peace of the county where they live. A justice is to exercise his authority only within the county where he is appointed by his commission, not in any city which is a county of itself, or town corporate, having their proper justices, &c. but in other towns and liberties he may. The power and office of justices terminates in six months after the demise of the crown, by an express writ of discharge under the great seal, by writ of supersedeas, by a new commission, and by accession of the office of sheriff or coroner.

Justices of the Peace within Liberties, are justices of the peace who have the same authority in cities or other corporate towns as the others have in counties, and their power is the same, only that these have the assize of ale and beer, wood, and victuals, &c. Justices of cities and corporations are not within the qualification act, 5 Geo. II. cap. 18.

JUSTIFICATION, in Law, signifies a maintaining or shewing a sufficient reason in court, why the defendant did what he is called to answer. Pleas in justification must set forth some special matter: thus, on being sued for a trespass, a person may justify it, by proving that the land is his own freehold; that he entered a house, in order to apprehend a felon; or by virtue of a warrant to levy a forfeiture, or in order to make a distress; and in an assault, that he did it out of necessity.

Justification, in Theology, that act of grace which renders a man just in the sight of God, and worthy of eternal happiness. *See* Theology. Different sects of Christians hold very different opinions concerning the doctrine of justification; some contending for justification by faith alone and others by good works.

K.

K, or k, the tenth letter of our alphabet; as a number denotes 250, and with a line over it, 250,000.

KÆMPFERIA. There are two species, *viz.* K. galangale; and K. rotunda, natives of the East Indies.

KALEIDOSCOPE, an instrument for creating and exhibiting an infinite variety of beautiful forms, and constructed in such a manner as either to please the eye, by an ever-varying succession of splendid tints and symmetrical forms, or to enable the observer to render permanent such as may appear most appropriate for any of the numerous branches of the ornamental arts.

This instrument, the invention of Dr. Brewster, in its most common form, consists of a tin tube, containing two reflecting surfaces inclined to each other, at any angle which is an aliquot part of 360°. The reflecting surfaces may be two plates of glass, plain or quicksilvered, or two metallic surfaces, from which the light suffers total reflection. The plates should vary in length according to the focal distance of the eye; five, six, seven, eight, nine, and ten inches, will in general be most convenient, or they may be made only one, two, three, or four inches long, provided distinct vision is obtained at one end, by placing at the other an eye-glass, whose focal length is equal to the length of the reflecting planes. The inclination of the reflector that is in general most pleasing is 18°, 20°, or 22½°, or the 20th, 18th, and 16th part of a circle, but the planes may be set at any required angle, either by a metallic, a paper, or cloth joint, or any other simple contrivance. When the two planes are put together, with their straightest and smoothest edge in contact, they will have the form shewn in fig. 1, where A B C is the aperture or angle formed by the plates. In this figure the plates are rectangular, but it may often be more convenient to give them the triangular form shewn at M. fig. 2, or N. fig. 3.

Fig. 1.

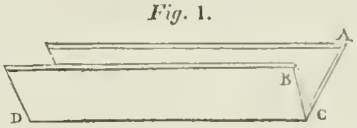


Fig. 2.

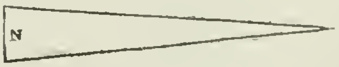
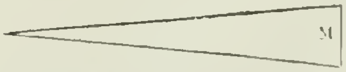


Fig. 3.



When the instrument is thus constructed, it may be either covered up with paper or leather, or placed in a cylindrical, or any other tube, so that the aperture A B C may be left completely open, and also a small aperture at the angular point D. If the eye is now placed at D, and looks through the aperture A B C, it will perceive a brilliant circle of light, divided into as many sectors as the number of times that the angle of the reflectors is contained in 360°. If this angle is 18°, the number of sectors will be 20°; and, whatever be the form of the aperture ABC, the luminous space seen through the instrument will be a figure produced by the arrangement of twenty of these apertures round C, as a centre, in consequence of the successive reflections between the polished surfaces. Hence it follows, that if any object, however ugly or irregular in itself, is placed before the aperture A B C, the part of it that can be seen through the aperture will be seen also in every sector, and every image of the object will coalesce into a form mathematically symmetrical, and highly pleasing to the eye. If the object be put in motion, the combination of images will likewise be put in motion, and new forms, perfectly different, but equally symmetrical, will successively present themselves, sometimes vanishing in the centre, sometimes emerging from it, and sometimes playing around in double and opposite oscillations. When the object is tinged with different colours, the most beautiful tints are developed in succession, and the whole figure delights the eye by the perfection of its forms and the brilliancy of its colouring.

The motion of the object may be effected either by the hand or by a simple piece of mechanism, or the same effect may be produced by the motion of the instrument over the object, or round its own axis. In the form of the kaleidoscope now described, the object should be held close to the aperture A B C, and the eye should be placed as nearly as possible in the line C D; for the figure loses its symmetry in proportion as the object recedes from A B C, and as the eye rises above D. The instrument is therefore limited in its present form to the use of objects which can be held close to the aperture.

In order to remove the limitation, the tube which contains the reflectors should slide in another tube, of nearly the same length, and having a convex lens at its farther extremity, the focal length of the lens should be always less than its greatest distance from the aperture A B C. In general it should be about one-third or one-fourth of that distance, but it will be advisable to have two or even three lenses of different focal lengths, to fit into the end of the outer tube, and to be used as circumstances may require, or a variation of focal length may be produced by the separation or approach of two lenses. When the instrument is thus fitted up, it may be applied to objects at all distances; and these objects, whose images are formed in an inverted position at the aperture A B C, may be introduced into the symmetrical picture in the very same manner as if they were brought close to the instrument. Hence we can introduce trees, flowers, statues, and living animals; and any object which is too large to be comprehended by the aperture A B C may be removed to such a distance that its image is sufficiently reduced.

The kaleidoscope is also constructed with three or more reflecting planes, which may be arranged in various ways. The tints placed before the aperture may be the complementary colours produced by transmitting polarised light through regularly crystallized bodies, or pieces of glass that have received the polarising structure. The partial polarisation of the light, by the successive reflections, occasions a partial analysis of the transmitted light; but, in order to develop the tints with brilliancy, the analysis of the light must precede its admission into the aperture. Instead of looking through the extremity D of the tube, the effects which have been described may be exhibited to many persons at once, upon the principle of the solar microscope or magic lantern; and in this way, or by the application of the camera lucida, the figures may be accurately delineated.

It would be an endless task to point out the various purposes in the ornamental arts to which the kaleidoscope is applicable. It may be sufficient to state, that it will be of great use to architects, ornamental painters, plasterers, jewellers, carvers and gilders, cabinet-makers, wire-workers, bookbinders, calico-printers, carpet manufacturers, manufacturers of pottery, and every other profession in which ornamental patterns are required. The painter may introduce the very colours which he is to use; the jeweller, the jewels which he is to arrange, and in general the artist may apply to the instrument the materials which he is to embody, and thus form the most correct opinion of their effect when combined into an ornamental pattern. When the instrument is thus applied, an infinity of patterns is created, and the artist can select such as he considers most suitable to his work. When a knowledge of the nature and powers of the instrument has been acquired by a little practice, he will be able to give any character to the pattern that he chooses, and he may even create a series of different patterns, all rising out of one another, and returning by similar gradations to the first pattern of the series. In all these cases the pattern is perfectly symmetrical round a centre, or all the images of the aperture A B C are exactly alike, but this symmetry may be altered, for after the pattern is drawn it may be reduced into a square, a triangular, an elliptical, or any other form that he pleases. The instrument will give annular patterns, by keeping the reflectors separate, as at A B, fig. 4, and it will give rectilineal ones, by placing the reflectors parallel to each other, as in fig. 5.

Fig. 4.

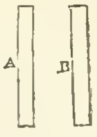
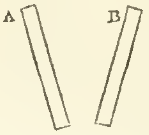
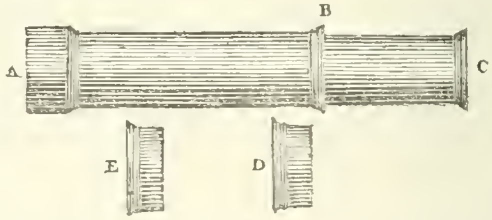


Fig. 5.



The kaleidoscope is also an instrument of amusement, to please the eye, by the creation and exhibition of beautiful forms, in the same manner as the ear is delighted by the combination of musical sounds. When Custillon proposed the construction of an ocular harpsichord, he was mistaken in supposing that any combination of harmonic colours could afford pleasure to the person who viewed them; for it is only when these colours are connected with regular and beautiful forms, that the eye is gratified by the combination. The kaleidoscope, therefore, seems to realize the idea of an ocular harpsichord.

Since the above was invented, another instrument of this class has been invented by Harris and Co. Holborn, London. This instrument generally consists of two tubes, A B and B C, one of which, B C, is moveable within the other, C being the end next the eye, and A the end next the object. The object cell D is made to screw in the collar A, as is also the lens E. In using the instrument, place the object cell D in the collar A as far as it can go, push in the tube B C *completely*, holding the instrument so that the sharp point of the triangular aperture at C is downwards. The instrument being now kept steady in the hand, turn round the collar A, and by placing the eye at C, will be seen a succession of the most beautiful forms and patterns. Hitherto it has been necessary to hold the object as close as possible to the end A of the tube, and to push in the tube B C as far as it would go, but the instrument is adapted to create forms and patterns by means of animate as well as inanimate objects, placed at all distances from the observer. This great advantage is obtained by the lens E and the sliding tube B C. The cell D is now removed, and the lens E being screwed into its place, any object whatever may be introduced into the patterns, merely by directing the instrument towards it, and pulling out or pushing in the tube B till the pattern is perfect. When the object is about four inches from the lens, the tube requires to be pulled out as far as possible, and for greater distances it must be pushed in. In looking at opaque objects, as a seal, watch-chain, the second hands of a watch, coins, pictures, gems, shells, flowers, leaves, and petals of plants, impressions from seals, &c. &c. the object, instead of being held between the eye and the light, must be viewed in the same manner as we view objects through a microscope, being placed as near the instrument as possible, so as to allow the light to fall freely upon the object.



In most of the instruments there is, near the middle of the tube B C, a mark which is nearly suited to all distances beyond *three feet*. The object cell D, held in the hand at a distance greater than five or six inches, may be also used when the lens E is in the tube. The furniture of a room, books, and papers laying on a table, pictures on a wall, a blazing fire, the moving foliage of trees, &c. bunches of flowers, horses and cattle in a park, carriages in motion, the currents of a river, moving insects, and in short, every object in nature may be introduced by the aid of the lens, into the figures created by the instrument. As dust will (though the greatest care may be observed) collect upon the reflectors, it is advised, that the feather of a quill (well scalded, to take out the grease) be introduced at the end of the sliding draw B C, and drawn up and down until they are clean, holding the apex of the angular aperture upward, and the instrument a little inclined, the end A downward.

KALI, a genus of marine plants, which are burnt to procure alkali. *See* Alkali and Kelp.

KAMSIN, a hot southerly wind common in Egypt. It prevails more or less for fifty days.

KANGAROO, in Natural History, a singular animal found in New Holland. It is about the size of a sheep, covered with a short fur of a dark mouse colour. The head, neck, and shoulders, are very small, when compared with the other parts of the body. The tail is long, thick near the rump, and tapering towards the extremity. This animal has a false belly, in which its young are carried, and secured from danger. The fore legs are only about eight inches long, while the hind legs are twenty-two. Its progress is by jumps of great lengths, in an erect position. The head and ears have some affinity to those of a hare.

KEBLA, an appellation given by the Mahometans to that part of the world where the temple of Mecca is situated, towards which they are obliged to turn themselves when they pray.

KECKLING, or Kaickling, the art of winding or worming old rope, &c. about a cable, to preserve its surface from being fretted when it rubs against a ship's bow or fore foot, but more particularly it implies the winding of iron chains round the cable, to defend it from the friction of a rocky bottom, or from the ice.

KEDGE, or Kedger, a small anchor used to keep a ship steady and clear from her bower-anchor while she rides in a harbour or river, particularly at the turn of the tide, when she might otherwise drive over her principal anchor, and entangle the stock or flukes with her slack cable, so as to loosen it from the ground. The kedge anchors are also used to transport a ship, or remove her from one part of a harbour to another, being carried out from her in the long boat, and let go by means of ropes fastened to these anchors. They are also generally furnished with an iron stock, which is easily displaced for the conveniency of stowing. *See* Anchor, Warp, &c.

KEEL, the principal piece of timber in a ship, which is usually first laid on the blocks in building. By comparing the carcase of a ship to the skeleton of a human body, the keel appears as the back bone, and the timbers as the ribs. Accordingly the keel supports and unites the whole fabric, since the stem and stern posts, which are elevated on its ends, are, in some measure, a continuation of the keel, and serve to connect and enclose the extremities of the sides by transoms, as the keel forms and unites the bottom by timbers. The keel is generally composed of several thick pieces placed lengthways, which, after being scarfed together, are bolted and clinched upon the upper side.

False Keel, a strong thick piece of timber bolted to the bottom of the keel, which is very useful in preserving its lower side. The false keel is provided when the thick pieces which form the real keel cannot be procured large enough to give a sufficient depth thereto. In large ships of war the false keel is composed of two pieces, called the upper and lower false keels. The lowest plank in a ship's bottom, called the garboard streak, has its inner edge let into a groove or channel, cut longitudinally on the side of the keel; the depth of this channel is therefore regulated by the thickness of the garboard streak.

Keel, is also a name given to a low flat-bottomed vessel used in the river Tyne, to bring the coals down from Newcastle for loading the colliers; hence, a collier is said to carry so many keels of coals.

KEEL Hauling, a punishment inflicted for various offences in the Dutch navy. It is performed by suspending the culprit by a rope from one yard-arm, with a weight of lead or iron upon his legs, and having another rope fastened to him, leading under the ship's bottom, and through a block at its opposite yard-arm; he is then suddenly let fall from the one yard-arm into the sea, where, passing under the ship's bottom, he is hoisted up on the opposite side of the vessel to the other.—This punishment is not altogether unknown in British ships, but, as it is dangerous, it is very rarely, or indeed scarcely ever, now practised.

KEELSON, or Kelson, a piece of timber forming the interior or counterpart of the keel, being laid upon the middle of the floor timbers immediately over the keel, and serving to bind and unite the former to the latter, by means of long bolts driven from without, and clinched on the upper side of the keelson. The keelson, like the keel, is composed of several pieces scarfed together; and in order to fit with more security upon the floor timbers and crotchets, it is notched about an inch and a half deep, opposite to each of those pieces, thereby scored down upon them to that depth, where it is secured by spikenails. The pieces of which it is formed are only half the breadth and thickness of those of the keel.

KEEP, in ancient military history, a kind of strong tower, which was built in the centre of a castle or fort, to which the besieged retreated, and made their last efforts of defence. It is also called the donjon, or dungeon. *See* Castle.

To Keep, a term used on several occasions in Navigation, as—*To Keep the Land Aboard*, is to keep within sight of land as much as possible. *To Keep the Luff*, or *the Wind*, to continue close to the wind; *i. e.* sailing with a course inclined to the direction of the wind as much as possible. *To Keep Off*, to sail at a distance from the shore or a ship, &c. *See* the article Offing.

KEEPER of the Great Seal, is a lord by virtue of his office, and styled the Lord Keeper of the Great Seal of England. He is one of the King's Privy Council, &c. through whose hands pass all charters, commissions, and grants of the king under the great seal; without which, such instruments are of no force.

Keeper *of the Privy Seal*, is a lord by virtue of his office, through whose hands pass all charters signed by the king before they come to the great seal.

Boat Keeper, one of the boat's crew who remains as a sentinel, in his turn, to take care of the boat and her contents when she is ashore, or alongside of a ship, or is towed astern of her.

KEEPING, in Painting, denotes the representation of objects in the same manner that they appear to the eye at different distances from it, for which the painter should have recourse to the rules of Perspective. There are two instances in which the famous Raphael Urbin has transgressed these rules: in one of his cartoons, representing the miraculous draught of fishes, the men in each of the two boats appear of full size, the features of their face being strongly marked; and the boats are represented so small, and the men so big, that any one of them appears sufficient to sink either of the boats by his own bare weight; and the fowls on the shore are also drawn so big, as to seem very near the eye of the observer, who could not possibly, in that case, distinguish the features of the men in the distant boats. Or, supposing the observer to be in either of the boats, he could not see the eyes or beaks of the fowls on the shore.—The other instance occurs in his historical picture of our Saviour's transfiguration on the mount; where he is represented with those who were then with him, almost as large as the rest of his disciples at the foot of the mount, with the father and mother of the boy whom they brought to be cured; and the mother, though on her knees, is more than half as tall as the mount is high. So that the mount appears only of the size of a little hay-rick, with a few people on its top, and a greater number at its bottom on the ground; in which case, a spectator at a little distance could as well distinguish the features of those at the top as those on the ground. But upon any large eminence, deserving the name of a mount, that would be quite impossible.

KEILL, Dr. John, an eminent mathematician and philosopher, was born at Edinburgh in 1671; and studied in the university of that city. Keill was author of several works, but was more distinguished in his time for the conspicuous part he took in the dispute between Leibnitz and Newton concerning the invention of fluxions.

KELP, a term which is used in Britain to signify the saline substance obtained by burning seaweed, which is chiefly employed in the manufacture of green glass. Different species of seaweed, belonging to the genus Fucus, and order Algæ, are cultivated for this purpose. These plants are thrown on the rocks and shores in great abundance, and in the summer are raked together, and dried as hay in the sun and wind, and afterward burnt to the ashes called *kelp*. The process of making it is thus:—The rocks, which are dry at low water, are the beds of a great quantity of seaweed, which is cut, carried to the beach, and dried; a hollow is dug in the ground three or four feet wide; round its margin are laid a row of stones, on which the seaweed is placed, and set on fire within, and quantities of this fuel being continually heaped upon the circle, there is in the centre a perpetual flame, from which a liquid, like melted metal, drops into the hollow beneath; when it is full, as it commonly is ere the close of the day, all heterogeneous matter being removed, the kelp is wrought with iron rakes, and brought to a uniform consistence in a state of fusion. When cool, it consolidates into a heavy dark-coloured alkaline substance, which undergoes in the glass-houses a second vitrification, and, when pure, assumes a perfect transparency. *See* Chemistry and Soda.

KENTLEDGE, pigs of iron for ballast, laid upon the floor, near the keelson, fore and aft.

Limber Kentledge, pigs of iron or lead, cast to fit between the floor timbers, or in the limbers.

KEPLER, John, a very eminent astronomer and mathematician, was born in the duchy of Wirtemberg in 1571. To him we owe the discovery of the true figure of the orbits, and the proportion of the motions of the solar system. This astronomer had a particular passion for finding analogies and harmonies in nature, after the manner of the Pythagoreans and Platonists. The great sagacity of this astronomer in the planetary motions, suggested to him some views of the true principles from which these motions flow. He speaks of gravity as of a power that was mutual between bodies; and says, that the earth and moon tend towards each other, and would meet in a point so many times nearer to the earth than to the moon, as the earth is greater than the moon, if their motions did not hinder it. He adds also, that the tide arises from the gravity of the waters towards the moon. But not having notions sufficiently just of the laws of motion, he was unable to make the best use of these ideas.

Kepler's *Laws*, a term used by astronomers to denote certain analogies between the distances of the planetary bodies and their times of periodic revolution, as also between the rate of motion of any revolving body, whether primary or secondary, and its distance from the central body about which it revolves; to which may also be added, the figure of the planetary orbits, and the position of the central body; these, in the order in which they were discovered, stand as follows:—1. Equal areas are described in equal times: that is, if a line be supposed to join the central and revolving body, this line passes over or describes equal areas in equal times, whether the planet be in its aphelion, perihelion, or any other part of its orbit. 2. The planets all revolve in elliptic orbits, situated in planes passing through the centre of the sun; the latter body occupying one of the foci of the ellipse. 3. The squares of the times of revolution of the several planetary bodies, are as the cubes of their respective distances from the sun.

Kepler's *Problem*, is the determining the true from the mean anomaly of a planet, or the determining its place in the elliptic orbit answering to any given time; and so named from the celebrated astronomer Kepler, who first proposed it. The general state of the problem is this: to find the position of a right line, which, passing through one of the foci of an ellipse shall cut off an area, which shall be in any given proportion to the whole area of the ellipse; which results from this property, that such line sweeps areas that are proportional to the times.

KERMES, in Zöology, the name of an insect produced in the excrescences of a species of the oak. *See* Coccus.

Kermes, *Mineral*, so called from its colour, which resembles that of a vegetable: kermes is one of the antimonial preparations. *See* Chemistry and Materia Medica.

KERSEY, John, an able English mathematician, who flourished towards the close of the seventeenth and beginning of the eighteenth century, and is chiefly known in the scientific world by his "Elements of Algebra," in two vols. folio, which is an ample and complete work, containing a full explanation of the problems of Diophantus; he was author likewise of "Dictionarum Anglo-Britanicum," or General English Dictionary.

KETCH, a vessel equipped with two masts, *viz.* the main-mast and the mizzen-mast, and usually from 100 to 250 tons burden. Ketches are principally used as yachts for conveying princes of the blood, ambassadors, or other great personages, from one place to another. Ketches are likewise used as bomb-vessels, and are therefore furnished with all the apparatus necessary for a vigorous bombardment.—*Bomb-ketches*, are built remarkably strong, as being fitted with a greater number of riders than any other vessel of war; and indeed this reinforcement is absolutely necessary to sustain the violent shock produced by the discharge of their mortars, which would otherwise in a very short time shatter them all to pieces.

KEVELS, or Shevils, a frame composed of two pieces of timber, whose lower ends rest in a sort of step or foot, nailed to the ship's side, from whence the upper ends branch outward into the arms or horns, serving to belay the sheets or great ropes by which the bottoms of the main-sail and fore-sail are extended.

Kevel-Heads, the ends of the top timbers, which rising above the gunnel serve to belay the ropes, or take a round turn to hold on.

KEY, or Key Note, in Music, a certain fundamental note or tone, to which the whole of a movement has a certain relation or bearing, to which all its modulations are referred and accommodated, and in which it both begins and ends. There are but two species of keys: one of the major, and one of the minor mode; all the keys in which we employ sharps or flats being deduced from the natural keys of C major and A minor; of which they are mere transpositions.

KEYS of an Organ, moveable projecting levers in the front of an organ, so placed as to conveniently receive the fingers of the performer, and which, by a connected movement with the valves or pallets, admit or exclude the wind from the pipes. *See* Organ.

Key *Stone* of an arch or vault, that placed at the top or vertex of an arch, to bind the two sweeps together. This, in the Tuscan and Doric orders, is only a plane stone, projecting a little; in the Ionic, it is cut and waved somewhat like consoles; and in the Corinthian and Composite orders, it is a console, enriched with sculpture.

Key, an instrument for the opening of locks. *See* Lock. The invention of keys is owing to one Theodore of Samos, according to Pliny and Polydore Virgil: but this must be a mistake, the use of keys having been known before the siege of Troy; mention even seems made of them in the 19th chapter of Genesis. Molinus is of opinion, that keys at first only served for the untying certain knots wherewith mankind anciently secured their doors: but there were keys, he maintains, in use nearly akin to our own; they consisted of three single teeth, and made the figure of an E; of which form there are still some to be seen in the cabinets of the curious.

Key, or *Quay*, a long wharf by the side of a harbour or river, usually built of stone, and having several store-houses for the convenience of lading and discharging merchant ships. It is furnished with posts and rings, whereby ships may be secured, as also with cranes, capstans, &c. to load or unload the vessels which lie alongside.

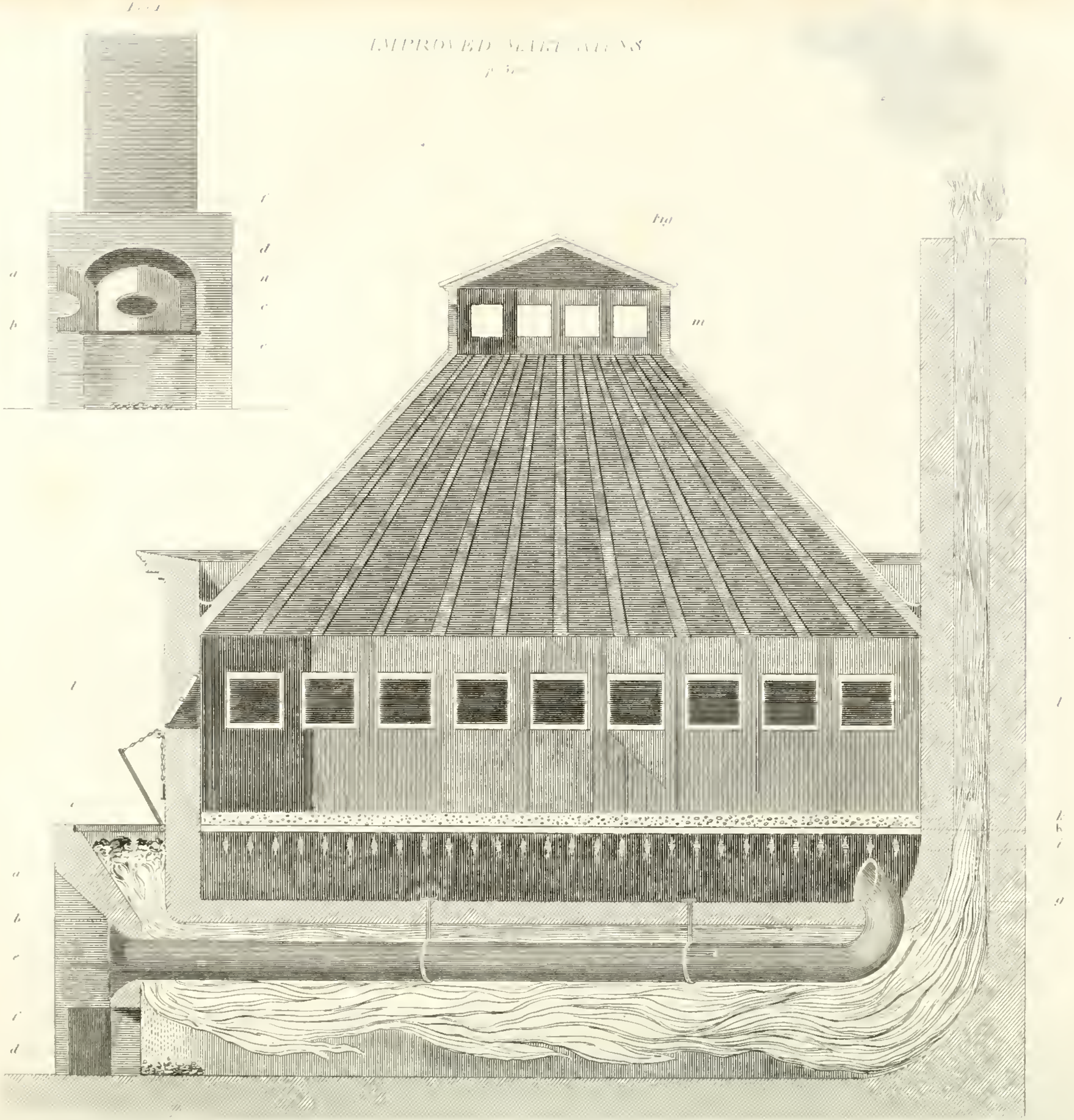
Keys, are also certain sunken rocks, lying near the surface of the water, particularly in the West Indies.

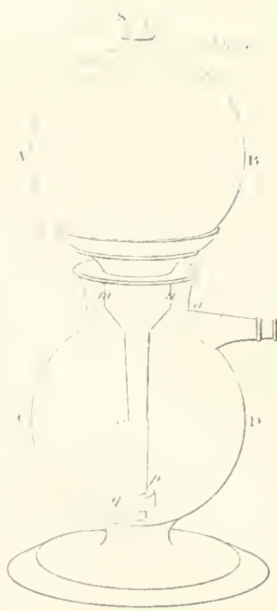
KIDNAPPING, is the forcibly taking and carrying away a man, woman, or child, from their own country, and sending them to another. This is an offence at common law, and punishable by fine, imprisonment, and pillory. By statute 11 and 12 William III. c. 7, if any captain of a merchant vessel shall during his being abroad, force any person on shore, and wilfully leave him behind, or refuse to bring home all such men as he carried out, if able and desirous to return, he shall suffer three months' imprisonment. Exclusive of the above punishment for this as a criminal offence, the party may recover upon an action for compensation in damages for the civil injury.

KIEFEKIL, a mineral dug up near Konie, in Natolia, and is employed in forming the bowls of Turkish tobacco-pipes. It is found in a large fissure six feet wide, in gray calcareous earth. When fresh dug it is of the consistence of wax; it feels soft and greasy: its colour is yellow; its specific gravity 1·600; when thrown on the fire, it sweats, emits a fetid vapour, becomes hard, and perfectly white. According to the analysis of Klap-

IMPROVED MALT KILNS

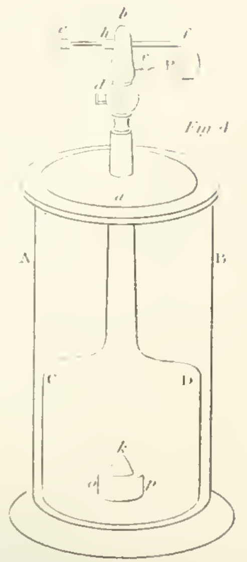
p. 5





DOBEREINER LAMPS.

See Page 419



roth, it is composed of 50·50 silica; 17·25 magnesia; 25·00 water; 5·00 carbonic acid; and 50 lime.

KILDERKIN, a liquor measure containing 18 gallons beer measure, and 16 gallons ale measure.

KILN.—*Description of a Vertical Kiln for Drying Corn. By Mr. James Jones, of Holborn, London.*—No subjects which can be brought under the consideration of society, combine more real interest and importance than those which involve the production and preservation of the chief necessaries of human life; in this view, the great value of a speedy and effectual method of drying grain is evident. The frequent occurrence of crops being, on account of unfavourable weather, necessarily carried from the field in a state of considerable humidity, every one must be aware of; and the consequent reduction in the value of the produce, arising from the deterioration in its quality, cannot be less evident. The heat generated by the fermentation in the heap, together with the moisture, causes germination to take place in the grains near the surface, whereby the farina is decomposed, and the nutritive properties are in a great measure destroyed, whilst the lower part becomes mouldy, and acquires a musty smell, of the most foul and disgusting kind; but grain laid up in a perfectly dry state suffers no change, and history furnishes numerous instances of the discovery of ancient granaries, wherein the corn has been preserved, in the most perfect condition, for a long series of years; which, had it been stored in a state of dampness, would have inevitably been destroyed. This, in the time of wet harvests, renders essentially necessary some artificial means of speedily dissipating the moisture, which is so destructive if allowed to continue in the grain; and the only means of effecting this object has hitherto been by the use of the common kilns, but which, in very bad seasons, on account of the slowness of their operation, are not sufficiently numerous to answer the purpose to the extent required. As an appendage to large granaries, or corn stores, kilns are of infinite utility, both as affording the certain means of preserving the grain from any tendency to fermentation whilst lying in store, and fitting it for water-carriage by that degree of dryness which is absolutely necessary to prevent its heating on board, where the opportunities of turning it are so limited, if not altogether wanting, although the necessity of it is increased; and to the miller the use of a kiln is not less important, as, without a certain degree of dryness, the wheat will not grind freely, it clogs the stones, and good flour is not produced; and it is a very general practice with millers, who possess the means, to pass all wheat over the kiln when the flour is intended for water carriage; at least, it is the custom at some mills; and it is well known, that new flour of the finest quality, when damp, has a remarkable predisposition to encourage the propagation of those minute insects which are destructive of its good properties. From these prefatory remarks on mischief and loss arising from wheat and grain being housed when damp, we proceed to our description of the malt kiln.

The common kiln is so well known, that little need be said in the way of description, except to enable those who are unacquainted with its construction, to judge of the comparative merits of the old kiln and those hereafter described; suffice it to say, that it consists of a floor, usually composed of Bridgewater tiles, which are large square flat tiles, perforated with a great number of small holes; or otherways of iron plates perforated in the same way; or of wove wire work, either kind being supported on iron bearing-bars extending from wall to wall. Beneath this floor or kiln head, as it is frequently called, are built four portions of arches of brickwork, which together compose a form somewhat similar to an inverted frustum of a pyramid, whose larger base is equal to the area of the floor; and in the lesser base, which is supported on low walls, is placed, at the distance of five or six feet from the tiles, a fire composed of coke, culm, or other suitable fuel: the heated air and vapour from which ascends into the pyramidal space above it, spreading rather unequally over the inferior surface of the floor, passing through the perforations made in it, and through the interstices between the grain, which is spread in considerable thickness upon it; the lower part of the stratum thus necessarily gets considerably heated, and the humidity is evaporated. After a lapse of time, dependent on the state of the grain, it is turned over with a large wooden shovel, or scoop, for the purpose of removing those grains which were before at the top, nearer to the heated surface, and those which are sufficiently dried, to the top; and is then suffered to remain until it is fit to be turned again, if from its previous damp state that is necessary, or to be removed entirely from the kiln, when a fresh quantity is submited to the same operation. The length of time it lies on the kiln depends on the proportion of moisture contained in the grain, and varies from five to eight or nine hours; indeed, Tull states the occasional necessity of extending it as far as twelve hours. On the kilns in use, previously to recent improvements, the average time required for the purpose was seven hours and a half, during which time four quarters and a half were dried, being at the rate of fourteen quarters and a half per day.

It must be evident that a stratum of wheat several inches thick, cannot be equally heated through all its parts in a short time, and, consequently, that the moisture which is expelled from the grains nearest the tiles, by the first effect of the fire, in the form of steam, must, in its ascent, be condensed and deposited on the colder grains which are nearer to or at the surface; and, consequently, so far as regards the upper part of the stratum, the evil is doubled, and until the grain is turned over, (unless that operation is excessively delayed,) the upper portion does not part with any of its previous or acquired moisture, and when it is turned, it must be allowed to remain long enough to evaporate, perhaps twice its original quantity of humidity, during which time the part which was first dried reabsorbs much of the moisture exhaled from the other grains, by which the time requisite to expel the whole is greatly extended. Whether any, or what chemical action takes place, detrimental to the flour in this protracted state of humid heat, we are not prepared to state; but it will not be doubted that the least possible time in which the purpose can be effected, the less chance there is of injurous change; and it will be admitted, that in those kilns heated by the direct action of the fire, the longer the grain remains, the more it will imbibe of the unpleasant effluvium arising from the fuel; but in kilns where the drying is performed by heated air alone, this objection does not exist. The operation of turning must obviously be an imperfect and inefficient one, notwithstanding every attention may be paid by the man performing it, for it is impossible he can turn the whole completely; but, from the circumstance of its being an unpleasant operation, it is seldom performed as effectually as it perhaps might be; but let the care and attention employed be unlimited, still, from the inequalities of the surface on which the grain lies, it is utterly impossible that the turning can be so complete, but that some of the grains remain undisturbed, and much is necessarily again brought into contact with the tiles, and therefore becomes over dried, to the injury of the entire quantity; and in fact the experience of every day shews the inequality of this mode of drying, as frequently, if not always, some of the grains are quite parched, whereby the quality of the flour is much injured, while others are thrown off the kiln almost as damp as when laid on.

That the imperfections here stated attach to the use of the common kiln, every person acquainted with the subject will acknowledge, and to such persons the communication of an effectual remedy will not be unacceptable.

In the latter part of the year 1821, Mr. Jones was applied to by John Snook, the proprietor of large mills at Bedhampton, Hants, to endeavour to effect some improvement in his kilns, so as, if possible, to obviate the existing objections; and although at that time he was perfectly unacquainted with the subject, very little reflection sufficed to convince him that the principles of the old method were bad; instead of attempting any alterations in the old kilns, after a good deal of consideration, he proposed the adoption of one altogether new, both in construction and in the manner of its operation, the exposure of a very thin stratum of grain, an equal temperature, the passage of a large quantity of warm air, and an uninterrupted removal or turning; each of which are indispensable where perfection is sought. This proposition of Mr. Jones was approved, and the first trial sufficiently proved the superiority of the new method over the old one, for the work it did, compared with one of the old kilns, which was at work a few days before, and with the same wheat, was rather more than as six to one.

The drawings explanatory of the machine are, fig. 1, (see plate), an elevation, fig. 2, a vertical section through the line *a b*. Fig. 3, a horizontal section through the line *c d*, and fig. 4, a vertical section of the fireplace on the line *e f*. The same letters indicate the same parts in each figure. The body of the kiln is composed of two concentric cylinders A A and B B, closed at top and bottom by two concentric cones C C and D D, the external cylinder, and the bases of its two cones, are six feet two and a half inches diameter, and eight feet high; the internal cylinder and its two cones are six feet diameter, and seven feet ten inches high; having an annular space, one inch and a quarter wide, between the internal and external bodies, which are perforated into iron plates, having 2300 small holes in each square foot. The kiln is supported on five cast iron columns E, E, E, E, E, six feet six inches high, which are attached at their tops to a strong iron ring which surrounds the base of the cylinder. From the heads of these columns descend along the sides of the cone five long bolts G, G, G, G, G, which are passed through the same number of lugs in the cast iron ring H, which surrounds the neck of the lower cone; from the same ring H also proceed five stays I, I, I, I, I, which are fastened through the middle of the columns by a nut on each side. The columns were made of the height here stated, for the purpose of enabling the wheat to be received into sacks, that being the most convenient under the particular circumstances; but in a mill where an elevator is near at hand, or where it would not be inconvenient to allow the wheat to run on the floor, the whole kiln might be brought lower down, and as great a length of cylinder as the height of the granary floor will admit of, may be used, as by the grain having a greater distance to descend, the motion would be more rapid, and, consequently, the turning will be more complete. The body is sustained both internally and externally by iron hoops K, K, K, and the distance between the cylinders is preserved by a number of short stays. When the kiln is in operation, the annular space before spoken of is entirely filled with wheat, by means of the spout W, from the granary, which keeps up a constant supply as fast as its exit is allowed at the discharging spout X, the opening of which is governed by a regulator, being adjusted to the time requisite to evaporate the moisture.

In the front of the kiln is cut out a space L, M, N, O, P, in which is fixed the fireplace L, M, O, P, in which Q is the firehole, and R, R, are openings with doors, for the purpose of cleaning the flues; S is the ash hole, and T the fire bars. On reference to the sections, it will be seen that there are vertical air-passages, round which the flame and heat of the fuel circulate to the right and left, until they reach the chimney, which rises through nearly the centre of the kiln; the course of the flame is evident, by the direction of the arrows, and in its passage to the chimney it very powerfully heats the plates which form the sides of the air-passages, and occasions a constant rush of hot air through them into the body of the kiln. The whole of the fireplace being enclosed within the kiln, it is entirely surrounded (excepting in the front) by a thin shell or casing of grain; and, from its perfect insulated situation, no part of its heat can escape, without having first performed its destined office. The triangular space or opening immediately over the fireplace answers two purposes, the chief of which is, diverting the wheat, as it descends, from coming too near the fire, whereby it would be parched, and it affords a convenient entrance into the kiln when requisite. The front part of the fireplace is supported on the heads of the two front columns, and the hinder part within the kiln by the pillar *g*, the top of which is fixed in a socket in a bearing-bar across the bottom of the fire place, and the lower end stands in a cup in the intersection of an iron cross, which rests in the ring, H, before mentioned, and the weight of the fireplace (nearly 15 cwt.) is consequently sustained by the bolts G, G, which descend from the heads of all the columns.

From this description, together with the drawing, the construction will be easily understood; and few words will be requisite to explain its operation. The fire having been lighted, the wheat is admitted from the granary, the regulator at bottom being for a few minutes kept shut; when, the annular space being full, the only way the warm air contained in the upper part of the kiln can escape, is through the holes in the iron, and the interstices between the grains; and as the stratum or shell of wheat is so thin, the passage of air is very rapid, and consequently the moisture is taken up by it, and carried off with the utmost celerity. With regard to the motion or stirring it undergoes, a few words may be requisite. The apex of the cone (where the wheat enters) has the greatest heat; here it is in a state of constant diverging motion, rapid where the heat is greatest, and progressively slower as the temperature diminishes, until it reaches the cylinders, where the motion becomes equable. Here the wheat would perhaps descend bodily, but the roughness left by the punching of the holes in the iron plate, is highly useful, as the little resistance it offers to the grain sliding down produces a constant, slow, rolling intestine motion, whereby every individual grain is exposed to the same degree of temperature; it then again converges in the lower cone, producing the same turning and mixing motion, as in the upper cone, and ultimately escapes through the spout at the bottom either into sacks or on the ground, as may be desired. Evaporation is at first strongly excited, and then gently kept up by a progressively decreasing temperature, as the grain descends towards the discharging spout; during the time the kiln is at work, the operation of screening is to a certain extent constantly going on, by which much of the dust, seed, insects, and other extraneous matters, are separated; and it is well known that grain cannot be too well screened from all impurities previous to storing, as its perfect preservation depends much on that circumstance. The rapidity of its operation is such, that the grain flows from it perfectly dried, at the rate of 29 loads, or 145 quarters, per day; which can only be accounted for by the circumstance of the aqueous vapour being carried clear away at once, without any part of it being deposited on other grains, and from the great quantity and rapidity of the current of warm air which constantly passes between the grains, taking up the humidity as fast as it is converted into vapour. It is dried with perfect equality, and above all, the quantity dried is six or seven times as great as by the common method; for the kiln which was removed to make room for the new one, dried (as before stated) on the average, fourteen quarters and a half per day, the medium quantity being 95 quarters: then as 95 : 14·5 : : 6·5 : 1. Or if we take the quantities before mentioned, the proportion will be as ten to one. For as 145 : 14·5 : : 10 : 1. This to the corn-merchant is an advantage of much importance, as frequently, on sudden changes of the markets, it is desirable to ship the grain with the utmost despatch, but the shipment is often much delayed by the necessity of kiln-drying the cargo previous to loading the vessels; by which delay, arising from the tardiness of the common operation, the advantages of a good market are not unfrequently lost.

Improved Malt Kilns for drying Malt by heated Air.—The common malt kiln is a square building, widening gradually within from the fireplace to the floor on which the malt is laid. It may be compared to an inverted pyramid having a fireplace in its vertex, and its base covered by a floor, on which the malt is dried by the heat, and more or less smoke, which ascends from the fire beneath. The floor, as we have described it, consists of iron bars covered by tiles, which have large holes made nearly through them from the lower side, and then very small holes pricked quite through. In some kilns, webs of wire covered with hair cloth, are used instead of the perforated tiles. The fuel commonly used is either coke, or Welsh stone coal —sometimes wood—and the hot air that passes through the malt has previously passed through the naked fire; but in the improved kilns, of which we have given engravings, from the Parliamentary Report on the Distilleries in Scotland, the smoke and fumes of the fuel are prevented from coming to the malt; the air that dries it receiving its heat in passing through a heated cast-iron tube.

Fig. 1. (see plate) is a front view of an improved malt kiln, in which *a a*, is the furnace door, *b* the fire, through which the air rises, the grate being of the common kind; *c* a cast-iron tube, which passing through the fire, and having one end open to the external air, and the other open into the kiln, conveys heated air to the grain; *d*, a flue around the fire, in which air is also heated and conveyed to the grain; *e*, the ash pit; *f*, the chimney.

Fig. 2. A side view of a malt kiln, in which the grain is dried by heated air, as in fig. 1, but in which the air necessary for

Mr. Jas. Jones's Kiln for drying Grain.

Fig. 1

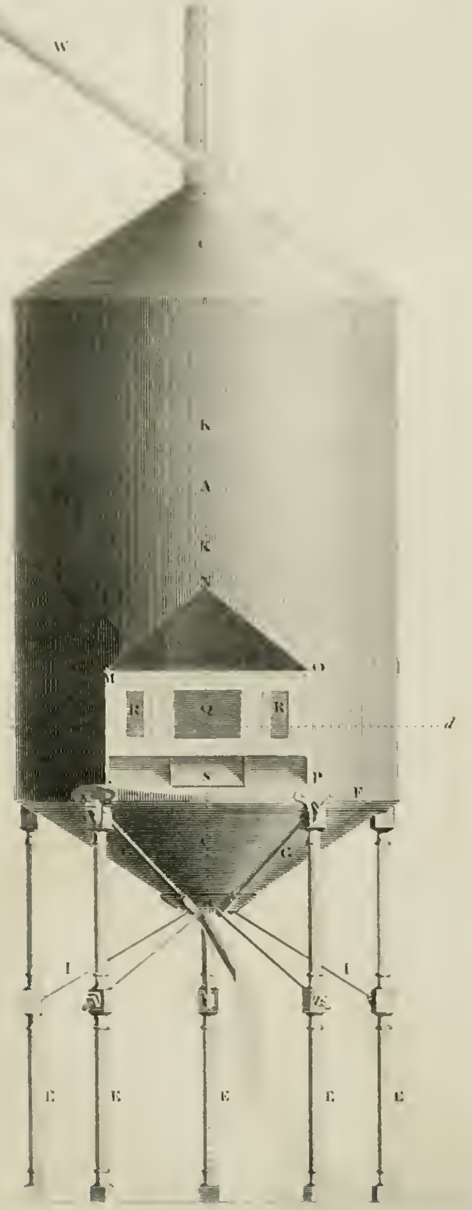


Fig. 4

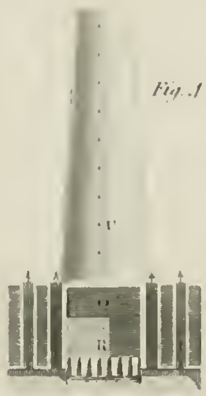


Fig. 3.

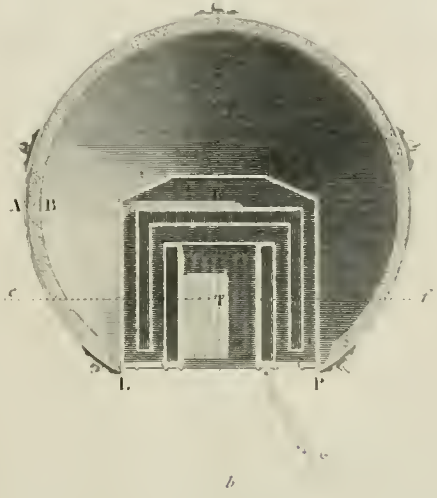
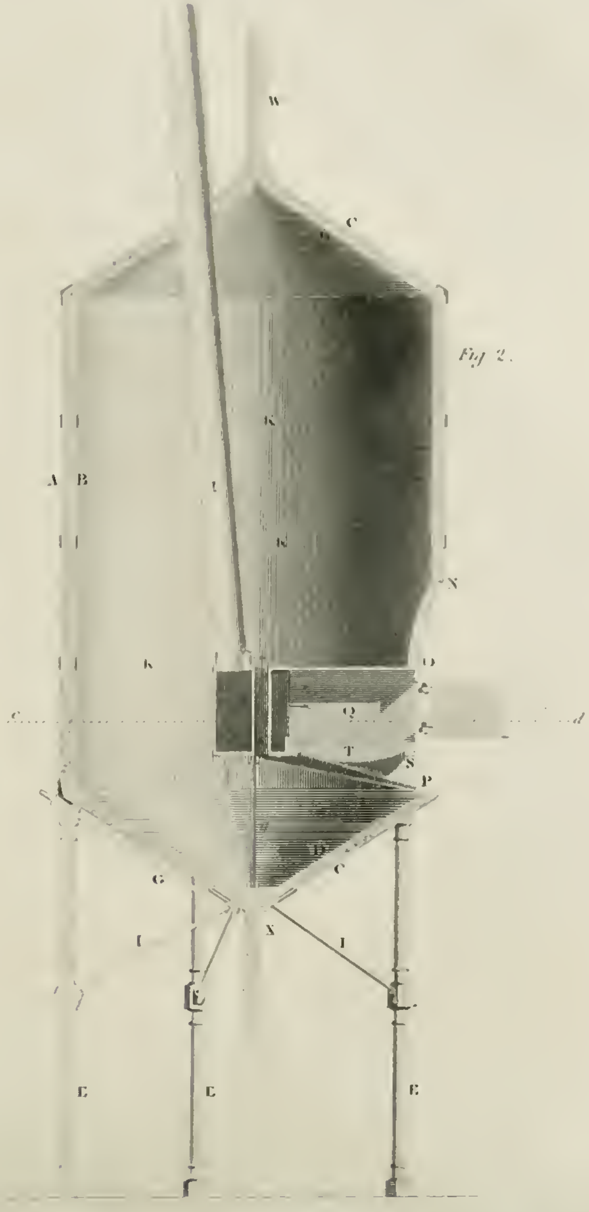


Fig. 2.



0 10 Feet

[illegible] on & C° Caxton London 1831

combustion of the fuel descends through the grate; *a*, the fire; *b*, the grate; *c*, the door of the furnace; *d*, the door of the ash pit; *e*, the air tube; *f*, the ash pit; *g*, the end of the air tube entering the space below *h*, the kiln head, which is composed of the tiles perforated with small holes, lying on the joists *i*, and supporting the malt *k*; *l l*, the windows, through which a current of air may freely enter or escape; *m*, the air outlets above. If a distiller finds his buildings so relatively situated that he can lead the air cylinder of his malt kiln through the flue of his still or mash boiler furnace, the expense of fuel for drying malt may be saved.

KINDRED. *See* INHERITANCE.

KING. The executive power in Great Britain and Ireland is vested in a single person. Formerly, the succession being interrupted, there was occasionally a distinction between a rightful king, or king *de jure*, and a king in possession of the throne, or king *de facto*; but it seems now only necessary to consider the rightful power and authority of the king, lawfully and peaceably in possession of the throne. And in this country the crown is by common law hereditary in a peculiar manner, but not *de jure divino*; and it may be changed into the limitation of its descent by the authority of the king, lords, and commons in parliament assembled, but it is not elective. It descends regularly to lineal descendants by right of primogeniture, but in case of no male heir, it descends to the eldest daughter only, and to her issue, and not in coparcenary to all the daughters. In failure of lineal heirs, it goes to collateral descendants, but there is no failure on account of half blood. Lands also purchased by the king descend with the crown. The inheritance is not indefeisible, but may be altered as above. But, however limited or transferred, it still retains its hereditable quality to the wearer of it, and hence the king never dies, but his right vests *eo instanti* in his heir. If the throne becomes vacant, whether by abdication, as in the time of James II. or by failure of all heirs, the two houses of parliament may dispose of it. It is now limited to the heirs of the princess Sophia, grand-daughter of James I. being protestant, and married to protestants.

To assist the king in the discharge of his duties and maintenance of his dignity, and exercise of his prerogative, he has several councils, as the *Parliament*, his *Peers*, and his *Privy Council*, which see. For law matters, the judges are his council. The principal duty of the king is to govern his people according to law; and in consideration of the duties incumbent on him, his dignity and prerogative are established by the laws of the land; it being a maxim in the law, that protection and subjection are reciprocal. *See* PREROGATIVE.

KING at ARMS, or of Arms, an officer who directs the heralds, presides at their chapters, and has the jurisdiction of armory. There are three kings of arms in England, *viz. Garter*, *Clarencieux*, and *Norry*, and one for Scotland, *viz. Lyon*.

KING'S *Bench*, is the supreme court of common law in England: and so called, because the king used to sit there in person; it consists of a chief justice, and three puisne justices, who are by their office the sovereign conservators of the peace, and supreme coroners of the land. This court has a peculiar jurisdiction, not only over all capital offences, but also over all other misdemeanors of a public nature, tending either to a breach of the peace, or to oppression or faction, or any manner of misgovernment. It has a discretionary power of inflicting exemplary punishment on offenders, either by fine, imprisonment, or other infamous punishment, as the nature of the crime, considered in all its circumstances, shall require.

The jurisdiction of this court is so transcendent, that it keeps all inferior jurisdictions within the bounds of their authority; and it may either remove their proceedings to be determined here, or prohibit their progress below; it superintends all civil corporations in the kingdom; commands magistrates and others to do what their duty requires, by mandamus, in every case where there is no specific remedy; protects the liberty of the subject, by speedy and summary interposition; and takes cognizance both of criminal and civil causes, the former in what is called the crown side, or crown office, the latter in the plea side of the court. This court has cognizance, on the plea side, of all actions of trespass, or other injury alleged to be commited *vi et armis*; of actions for forgery of deeds, maintenance, conspiracy, deceit; and actions on the case, which allege any falsity or fraud. In proceedings in this court the defendant is arrested for a supposed trespass, which in reality he has never committed, and being thus in the custody of the marshal of this court, the plaintiff is at liberty to proceed against him for any other personal injury, which surmise of being in the custody of the marshal the defendant is not at liberty to dispute. This court is likewise a court of appeal, into which may be removed, by writ of error, all determinations of the court of Common Pleas, and of all inferior courts of record in England.

KING'S *Palace*. The limits of the king's palace at Westminster extend from Charing-cross to Westminster-hall, and have such privileges as the ancient palaces.

KINK, a sort of twist or turn in any cable or rope, occasioned by its being very stiff, or close laid, or by being drawn too hastily out of the roll or tier in which it was coiled. *See* the article COILING.

KIRCHER, ATHANASIUS, a celebrated mathematician, was born at Fulde in 1601. He wrote an immense number of books, amounting altogether to twenty-two volumes folio, eleven quarto, and three octavo. It must, however, be allowed, that their utility bears no proportion to their magnitude, and it would therefore be useless to give a catalogue of them in this work, as there is no one of them but has been superseded by later authors. Kircher died in 1680, in his 80th year.

KITE, CAPTAIN DANSEY'S, for effecting a communication between a stranded ship and the shore, or under other circumstances, where badness of weather renders the ordinary means impracticable. A sail of light canvass or holland, is cut to the shape, and adapted for the application of the principles of the common flying kite, after the manner in which Dr. Franklin used to swim on his back in water; and is launched from the vessel or other point to windward of the space over which a communication is required, and as soon as it appears to be at a sufficient distance, a very simple and efficacious mechanical apparatus is used, to destroy its poise, and cause its immediate descent; the kite remaining, however, still attached to the line, and moored by a small anchor with which it is equipped. The kite during its flight is attached to the line by two cords placed in the usual manner, which preserve its poise in the air; and to cause its descent, a messenger is employed, made of wood, with a small sail rigged to it. The line being passed through the cylindrical hole of this messenger, the wind takes it rapidly up to the kite, where, striking against a part of the apparatus, it releases the upper cord, and by that means the head of the kite becomes reversed, and it descends with rapidity. In the experiments made by Captain Dansey, with a view of gaining a communication with a lee-shore, under the supposition of no assistance being there at hand, a grapnel, consisting of four spear-shaped iron spikes, was fixed to the head of the kite, so as to moor it in its fall; and in this emergency, the attempt of some person to get on shore along the line, would be the means resorted to. In those cases where a communication has been gained, and the maintenance of a correspondence has been the object, the person to windward has attached a weight to the messenger, in some cases as much as three pounds, which, having been carried up, has of course descended with the kite; the person to leeward has then furled the sail of the messenger, and loaded it with as much weight as the kite could lift, then replacing the apparatus, and exposing the surface of the kite to the direct action of the wind, it has rapidly risen, the messenger running down the line to windward during its ascent. The kite with which the Captain performed the greater part of his experiments, extended 1100 yards of line $\frac{3}{8}$ of an inch in circumference, and would have extended more, had it been at hand. It also extended 360 yards of line $1\frac{3}{4}$ inch in circumference, and weighing 60 lbs. The holland weighed $3\frac{1}{2}$ lbs.; the spars, one of which was armed at the head with iron spikes, for the purpose of mooring it, $6\frac{3}{4}$ lbs., and the tail was five times its length, composed of 8 lbs. of rope and 14 lbs. of elm plank. Captain Dansey has deposited a complete apparatus with the Society of Arts, who have very properly presented him with their gold Vulcan medal, for his valuable invention and communication.

KNAPSACK, a rough leather or canvass bag, which is strapped to an infantry soldier's back when he marches, and which contains his necessaries. Square knapsacks are supposed to be most convenient. They should be made with a division to hold the shoes, blacking-balls, and brushes, separate from the linen.

KNEADING Mill, is a contrivance by which large quantities of flour are mixed and incorporated into dough, in place of kneading it with the baker's feet, or by a large spatola. The kneading mill does this business very completely, with a great saving of time and labour. It is used at the public baking-houses of Genoa.

A, in fig. 4, is a frame of wood which supports the axis of the machine; a wall 14 palms high from the ground may be made use of instead of this frame. B, a wall three palms and a half thick, through which the aforesaid axis passes. C, another wall similar to the former, and facing it, at the distance of 21 palms. D, the axis, thirty palms in length, and one palm and one-third in thickness. E, the great wheel, fixed to the said axis, between the frame and the wall; its diameter is 28 palms, and its breadth, which is capable of holding two men occasionally, is five palms. F, are steps, by treading on which the men turn the wheel very smartly; they are two palms distant from each other, and one third of a palm in height. G, a small wheel with cogs fixed almost at the further extremity of the axis; its diameter is $12\frac{1}{2}$ palms. H, a beam of wood which extends from one wall to the other; being 21 palms in length, and one and a third in thickness. A similar beam, not seen in the figure, is on the opposite side of the axis. I, a transverse piece of wood, placed near the wall C; it is fixed into the two beams, and serves to support the further extremity of the axis: its length is 14 palms, and its thickness one and a third: there is likewise a transverse piece, which cannot be seen in the figure, 14 palms long, and half a palm thick, placed close to the wall B. K is a strong curved piece of oak, fixed transversely in the side beams H, to receive the axis of the trundle; its length is 14 palms, and its thickness $1\frac{1}{2}$. L is a trundle of $5\frac{1}{2}$ palms in diameter, and $1\frac{1}{4}$ in height, which is moved by the cogged-wheel G. M is an axis proceeding from the trundle L, and continued through the cross N to the bottom of the tub P; the centre is made of iron, partly square and partly round, and it turns in a socket of brass. The first part of this axis between the trundle L, and the cross N, is of square iron, surrounded by two pieces of wood, held together by iron hoops, which may be removed at pleasure, to examine the iron within; its length is three palms, its diameter about one palm. The second part of the axis, which is within the tube, is made like the first part; its height is $1\frac{1}{2}$ palm, its diameter $1\frac{1}{6}$. The wooden sheath of this part of the axis is fixed to the bottom of the tub, by means of three screws with their nuts. The axis is distant one-third of a palm from the nearest triangular beater of the cross. N, the cross formed of two bars of wood unequally divided, so that the four arms of the cross are of different lengths: one of the two pieces of wood of which the cross is made, is six palms in length, the other five: their thickness is $\frac{7}{12}$ of a palm, and their breadth one palm. O, four pieces of wood, called *beaters*, of a triangular shape, fixed vertically into the extremities of, and underneath, the arms of the fore-mentioned cross: they are $1\frac{3}{4}$ palms in length, and half a palm in thickness; and beat or knead the dough in the tub at an equal distance from the centre. P is a stout wooden tub about a quarter of a palm thick, well hooped with iron; its diameter is six palms, its height $1\frac{1}{2}$ in the clear.

Fig. 1.

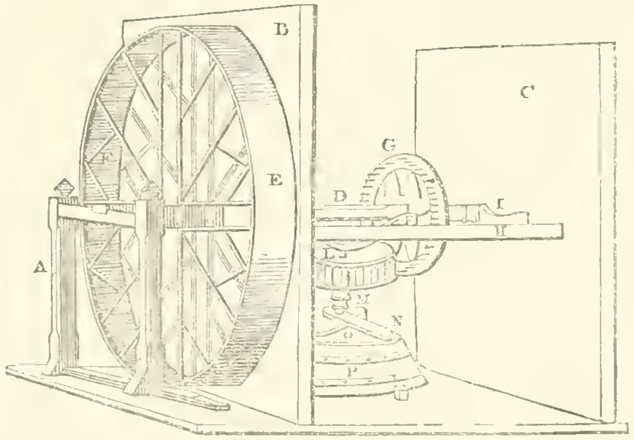


Fig. 2.

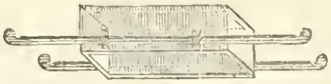


Fig. 2, is a box or trough of wood, four palms long, and three wide, in which the leaven is formed (in about an hour) in a stove, and in which it is afterwards carried to the tub P. Fig. 3, exhibits a view of the trundle, cross, &c. with a section of the tub. Fig. 4, is a bird's eye view of the cross and tub, with the upper ends of the triangular beaters.

This tub, P, will contain 18 rubbi (about 19 bushels) of flour, which is carried to it in barrels; the leaven is then carried to it in the box or trough, fig. 2, and when the whole is tempered with a proper quantity of warm water, the men work in the wheel till the dough is properly and completely kneaded. In general a quarter of an hour is sufficient to make very good dough; but an experienced baker, who superintends, determines that the operation shall be continued a few minutes more or less, according to circumstances. The measures in the preceding description are given in Genoese palms, each of which is very nearly equal to 9·85 of our inches. The machinery may be varied in its construction according to circumstances, and the energy of the first mover much better applied than by men walking in a common wheel.

Fig. 3.

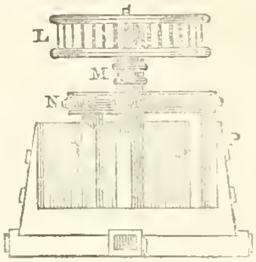
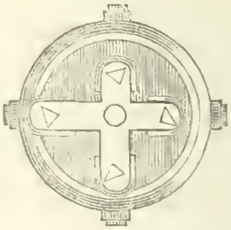


Fig. 4.



KNECK, the twisting of a rope or cable as it is veering out.

KNEE, a crooked piece of timber having two branches or arms, and generally used to connect the beams of a ship with her sides or timbers. The branches of the knees form an angle of greater or smaller extent, according to the mutual situation of the pieces which they are designed to unite. One branch is securely bolted to one of the deck-beams, and the other in the same manner strongly attached to a corresponding timber in the ship's side. Besides the great utility of knees in connecting the beams and timbers into one compact frame, they contribute greatly to the strength and solidity of the ship, in the different parts of her frame to which they are bolted, and thereby enable her, with great firmness, to resist the effects of a turbulent sea. In fixing of these pieces, it is occasionally necessary to give an oblique direction to the vertical or side branch, in order to avoid the range of an adjacent gun-port, or because the knee may be so shaped as to require this disposition, it being sometimes difficult to procure so great a variety of knees as may be necessary in the construction of a number of ships of war. In France, the scarcity of these pieces has frequently obliged their shipwrights to form their knees of iron.

Dagger Knees, are those which are fixed rather obliquely, to avoid, as above mentioned, an adjacent gun-port, or where, from the vicinity of the next beam, there is not space for the arms of two lodging knees.—*Hanging Knees*, are those which, from their situation under a deck, appear to support the beams.—*Iron Knees*, are frequently used in all the various applications instead of wooden ones, particularly in the French ships, on account of the scarcity of timber fit for the purpose.—*Lodging Knees*, are fixed horizontally in the ship's frame, having one arm bolted to the beam, and the other across two or three of the timbers.—*Standard Knees*, are those which, being upon a deck, have one arm bolted down to it, and the other pointing upwards, secured to the ship's side; such, also, are the bits and channels.—*Transom Knees*. *See* Transom.

Knee *of the Head*, a large flat piece of timber, fixed edgeways upon the foremost part of a ship's stem, and supporting the ornamental figure or image placed under the bowsprit. The knee of the head, which may properly be defined a continuation of the stem, as being prolonged from the stem forwards, is extremely broad at the upper part, and accordingly composed of several pieces united into one. It is let into the head, and secured to the ship's bows by strong knees fixed horizontally upon both, and called the cheeks of the head. The heel of it is scarfed to the upper end of the fore-top, and it is fastened to the stem above by a standard knee. Besides supporting the figure of the head, this piece is otherwise useful as serving to secure the boom or bumkin, by which the foretack is extended to windward, and by its great breadth preventing the ship from falling to leeward when close-hauled, so much as she would otherwise do. It also affords a greater security to the bowsprit, by increasing the angle of the bobstay, so as to make it act more perpendicularly on the bowsprit. The knee of the head, is a phrase peculiar to shipwrights; but, by seamen, it is called the cut-water. *See* Cut-water.

KNIFE, a well-known instrument, made for cutting, and adapted in form to the uses for which it is designed. Knives are said to have been first made in England in 1563, by one Matthews, on Fleet Bridge, London. The importation of all sorts of knives is prohibited.

KNIGHT, properly signifies a person, who, for his virtue and martial prowess, is by the king raised above the rank of gentlemen into a higher class of dignity and honour. The ceremonies at the creation of knights have been various: the principal was a box on the ear, and a stroke with the sword on the shoulder; they put on him a shoulder belt, and a gilt sword, spurs, and other military accoutrements; after which, being armed as a knight, he was led to the church in great pomp. Camden describes the manner of making a knight bachelor among us, which is the lowest, though the most ancient order of knighthood, to be thus: the person kneeling was gently struck on the shoulder by the prince, and accosted in these words, "Rise," or "Be a knight in the name of God." For the several kinds of knights among us, *See Banneret, Baronet, Bath, Garter*, &c.

KNIGHTS of the Shire, or Knights of Parliament, in the British polity, are two knights, or gentlemen of estate, who are elected on the king's writ, by the freeholders of every county, to represent them in parliament. The qualification of a knight of the shire is, to be possessed of 600*l.* per annum in a freehold estate.

KNIGHT-HEADS, also denote in a merchant ship two strong frames of timber, fixed on the opposite side of the main-deck, a little behind the fore-mast, which support and enclose the ends of the windlass, which accordingly is turned therein as upon an axis: as each of these is formed of two pieces, they may be occasionally separated, in order to take off the turns of the cable from the windlass, or replace them upon it. They are frequently called the bitts, and then their upper parts only are denominated knight-heads, which being formerly embellished with a figure, designed to resemble a human head, gave rise to a name they have ever since retained. *See* Windlass.

Knight-heads, was formerly a name given to the lower jear-blocks, which were then no other than bitts, containing several sheaves, and nearly resembling our present top-sail sheet-bitts.

KNITTLE, a small line composed of two or three rope-yarns, either plaited or twisted, and used for various purposes, particularly to fasten the service on the cable, to sling the sailors' hammocks, to reef the sails by the bottom, &c.

Knittle, is also a name given to the loops or buttons of a bonnet.

KNOCK-OFF, an order to cease any work.

KNOT, a large knob formed on the extremity of a rope, generally by untwisting the ends thereof, and interweaving them regularly among each other: of these there are several sorts, differing in form, size, and name, as shroud knot, stopper knot, overhand knot; single wall knot, wale knot, or walnut; double wall knot, wale knot, or walnut; diamond knot, kop knot, reef knot. The bow-line knot is so firmly made and fastened to the crengles of the sails, that they must break, or the sails split, before it will slip. The sheep-shank knot serves to shorten a rope without cutting it, which may be presently loosened. The wale knot is so made with the lays of a rope, that it cannot slip, and serves for sheals, tacks, and stoppers. The knots are generally used to act as a button in preventing the end of the rope from slipping through an eye, or through the turns of a laniard, by which they are sometimes made fast to other ropes.

Knot, also signifies the manner of tying two ropes together, or the end of a rope to a bight in the same.

Knot, also implies a division of the long-line, which answers to half a minute, as a mile does to an hour, *i. e.* $\frac{1}{120}$ of a mile: hence we say, the ship was going eight knots, which signifies eight miles per hour.

KNOUT, the name of a punishment inflicted in Russia, with a kind of whip called knout, and made of a long strap of leather prepared for the purpose. With this whip the executioners dexterously carry off a slip of skin from the neck to the bottom of the back laid bare to the waist, and repeating their blows, in a little while rend away all the skin of the back in parallel stripes. In the common knout, the criminal receives the lashes suspended on the back of one of the executioners; but in the great knout, which is generally used on the same occasions as racking on the wheel in France, the criminal is raised into the air by means of a pulley fixed to the gallows, and a cord fastened to the two wrists tied together; a piece of wood is placed between his two legs, also tied together, and another of a crucial form under his breast; sometimes his hands are tied behind over his back, and when he is pulled up in this position, his shoulders are dislocated. The executioners can make this punishment more or less severe; and it is said, are so dexterous, that when a criminal is condemned to die, they can make him expire at pleasure, either by *one* or *several* lashes.

KNOWLEDGE, is defined by Mr. Locke to be the perception of the connexion and agreement or disagreement and repugnancy of our ideas.

In his fifth book of the Grammar of Logic and Intellectual Philosophy, the Editor has given a Syllabus of the Philosophy of Human Knowledge, and the following Prospectus is, therefore, but a very limited draught of that abstract.

The Words History, Philosophy, and Poetry, taken in their most extensive meanings, may be said to comprehend every branch of human knowledge. But history addresses itself to the *Memory*; Philosophy, to the *Understanding*; and Poetry to the *Imagination*. The Philosophy of Human Knowledge will therefore be divided into three great compartments, adapted to these three faculties—the Memory, the Understanding, and the Imagination. According to this arrangement, Human Knowledge may be considered as it is addressed to the memory, under the title of History. But history is a word of extensive import, and suggests a subdivision of its materials into three parts, under the respective titles of *Sacred, Civil,* and *Natural History*. Under the first title, ecclesiastical history, the science of language arranges the narrative parts of revelation—the history of the Jews,—the propagation and the progress of Christianity, &c. Under the second title—*Civil*, or *Profane History*, Literary History, Memoirs, Annals, Biography, Antiquities, Chronology, and Geography, demands attention. The third title, which Lord Bacon calls *Narrative*, comprehends the following subordinate divisions, *viz.*—1. Productions of Nature, as the phenomena of the Heavens, the Atmosphere, and the Earth; 2. The three Kingdoms of Nature, as Minerals, Vegetables, and Animals; 3. A Delineation of the Mechanical Arts and Manufactures.

The Philosophy of Human Knowledge, addressed to the understanding, views all the sciences and the theories of all the arts, or, in other words, the Philosophy of the knowledge of *mind* and the knowledge of *body*.

In considering knowledge as referring to mind unconnected with body, or to mind and body connected, or to body unconnected with mind, we are led to the contemplation of the doctrines and principles which result from those attributes which revelation assigns to Deity, and thence to a delineation of the Philosophy of Natural Religion, and part of the science of Metaphysics.

The branches of knowledge relative to man and human nature, which belong to this division, respect either the faculties of his mind, or the use which he makes of those faculties: first, in acquiring and communicating knowledge; and secondly, in acquiring happiness. Thus we launch into a philosophical view of those sciences which embrace the general history of the faculties of the mind, and the exertions of those faculties in all that is valuable, in Logic, in Rhetoric, and in Morality. The terms logic and rhetoric are generally applied to intimate the philosophy of those arts in the cultivation of Taste, Criticism, the Belles Lettres, or polite Literature; and as their study qualifies us to determine the merits of compositions or works of art. *Morality*, or the science of happiness, divides itself into two distinct branches; one relative to individuals, and the other relative to communities. The former comprehends many important topics of investigation, founded on the principles of virtue, the laws of human conduct, obligations to integrity, and duties to our Creator, our neighbour, and ourselves. The second, the morality that regards communities, constitutes the science of politics, which resolves itself into three branches; the first containing the laws of peace and war, or the rules which guide the intercourse of communities, founded on the practice of civilized nations, and the dictates of equity; the second delineating the different civil governments which have been contrived or adopted, to secure the safety of states, with the prosperity and comfort of individuals; and the third exhibiting economical arrangements, or the laws which punish crimes, and encourage industry, and which protect and cherish commerce and the arts.

Human Knowledge, relative to body, animated or inanimate, is divided into three branches;—the first contains the metaphysics of body, or the philosophy of its general properties, extension, solidity, impenetrability, motion, &c. The second, regarding the surfaces of bodies, investigates the importance of the truths, and the value of the evidence, furnished by Arithmetic, Geometry, and Natural Philosophy. The third, viewing the internal parts of bodies, explains those branches of philosophy which regard, first, the general laws or properties of bodies; secondly, the internal structure of animals, with their diseases and cures; and thirdly, the ingredients or component parts of bodies. The first constitutes the science of Natural History; the second, Medicine; and the third, Chemistry.

The Philosophy of Human Knowledge, addressed to the Imagination, may be briefly quoted in the successive terms, Poetry, Sculpture, Architecture, Painting, Gardening, and Music.

The term Poetry is not, however, restricted to metrical compositions, but includes all ornamental and figurative compositions, addressed to the imagination and the heart. Under the title Sculpture, are comprehended the productions of antiquity which have served as models and standards of excellence to the moderns, and called forth their exertions to rival the age of Pericles, that æra of luxury and splendour, which gave it the title of the Golden Age of the arts in Greece. Statuary appears in three splendid æras; first, when it displayed itself with such surprising lustre in the productions of the antique statues; secondly, when it was revived under Leo X.; and lastly, in our own times, wherein we behold geniuses animated by a similar spirit of taste, and a similar solidity of judgment, as formed the Grecian painters Apelles and Zeuxis, and the sculptors Phidias and Praxiteles. On principles somewhat analagous, Knowledge extends to Architecture and Painting, but of Gardening and Music antiquity furnishes no standards or models of taste to the moderns, with which their acquirements may be compared.

Confining our views to the reality of knowledge, it is evident that the mind knows not things immediately, but by the intervention of the ideas it has of them. Our knowledge therefore, is only real, so far as there is a conformity between the reality of things and our ideas of that reality. Now there are two classes of ideas in which this agreement may be traced, and these are, our simple ideas, and those which are generally denominated complex.

As the human mind can by no means make to itself simple ideas, it is obvious that they must be the effect of things operating upon it in a natural way, and producing therein those perceptions, which by the will and appointment of God, they are adapted to produce. Hence, it follows, that simple ideas are not the fictions of fancy, but the natural and regular production of things without us, really operating upon us, and carrying with them all the conformity our state requires, which is to represent things under those appearances they are fitted to produce in us. Thus the idea of whiteness, as it is in the mind, exactly answers that power which is in any body to produce it there. Similar remarks may be made respecting all our simple ideas; and this conformity between them and the existence of things, is sufficient for the purposes of real knowledge.

All our complex ideas, excepting those of substances, which are involved in much obscurity, being archetypes of the mind's own making, and not referred to the existence of things, as to their originals, cannot want any conformity necessary to real knowledge; for that which is not designed to represent any thing but itself, can never be capable of any wrong representation.

Hence it appears, that our simple ideas produced by things without us, operating upon the senses, furnish the sterling materials of all our knowledge. The mental storehouse being thus enriched, the mind can combine, arrange, and associate them at pleasure, and thus trace agreements or disagreements in the combinations which it forms. By these means error can be detected, new truths elicited, and in this rich and fertile region, fancy can exercise her creative energy, and give birth to works of taste and genius.

Whatever ideas we have, the agreement we find they have with others will be knowledge. If those ideas be abstract, it will be general knowledge; but to make it real concerning substances, the ideas must be taken from the real existence of things. Wherever, therefore, we perceive the agreement or disagreement of our ideas, there is certain knowledge; and wherever we are sure those ideas agree with the reality of things, there is certain, real knowledge.

KORAN, or ALKORAN, the name of the book held equally sacred among the Mahometans, as the Bible is among Christians. The general aim of the Koran was, to unite the professors of the three different religions then followed in Arabia, Idolaters, Jews, and Christians, in the knowledge and worship of one God, under the sanction of certain laws, and the outward signs of ceremonies, partly of ancient, and partly of novel institution, enforced by the consideration of rewards and punishments, both temporal and eternal; and to bring all to the obedience of Mahomet, as the prophet and ambassador of God. The chief point therefore inculcated in the Koran is the unity of God, to restore which the prophet confessed was the chief end of his mission. The rest is taken up in prescribing necessary laws and directions, frequent admonitions to moral and divine virtues, the worship and reverence of the Supreme Being, and resignation to his will.

The style of the Koran is generally beautiful and fluent, concise, but often obscure, adorned with bold figures: enlightened with florid and sententious expressions; and in many places, especially where the majesty and attributes of God are described, sublime and magnificent. Among Mahometans this book is held in the greatest reverence and esteem. They suppose it to be of divine original, eternal, and uncreated; and that it was revealed to Mahomet by the angel Gabriel; dare not touch it without being first washed, or legally purified; and read it with great care and respect. They swear by it, take omens from it on all weighty occasions, carry it with them to war, write sentences of it on their banners, adorn it with gold and precious stones, and do not suffer it to be in the possession of any who hold a different religion. It has been translated into English.

KOS, in Jewish Antiquity, a measure of capacity, containing about four cubic inches; this was the cup of blessing, out of which they drank when they gave thanks after solemn meals, like that of the passover.

KUPFERNICKEL, is a sulphuret of nickel, and is generally compounded of nickel, arsenic, and sulphuret of iron.